Role of Iron in Horticultural crops

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Majority of the third world population suffers from iron deficiency, but the populations most affected are women of reproductive age & children (Robinson et al. 1999). Recent studies have revealed that iron deficiency is linked with impaired cognitive development. Plants are the principle source of iron in the majority of diets, so assuring consumption of vegetables & fruits with an adequate level of iron constitute an essential part of the strategy for improving the level of human nutrition (Theil et al. 1997). The aforesaid gains greater significance when referring to agricultural system in area with calcareous soil where the crops probably have sub optimum levels of iron.

Maximum horticultural crops are particularly susceptible to iron deficiency. This is of commercial importance in fruit trees like apple, pear, apricot, cherry, plum, lemon, orange, lime & mandarin; in berries like strawberry & grape & in vegetables like tomato, cucumber & bean. Other horticultural crops like rose, marigold, ornamentals & flower plants are also susceptible to iron deficiency. Iron is involved in the production of chlorophyll & it is a component of many enzymes associated with energy transfer, nitrogen reduction, fixation & lignin formation in different horticultural crops. The critical level of iron in soil is 4.5 mg kg-1 & in plant dry matter is 50 mg kg-1. The normal content of iron in the tissue of horticultural crops is 50-300 mg kg-1 (ppm) in plant dry material (Zuang, 1982). Olsen et al. (1981) mentioned that in general the content of iron required for a typical crop during the growing season is 5-10 kg ha-1. The content of iron in many soils is much higher than 5-10 kg ha-1 due to the problem with of low solubility of ionic form (Chen & Barak, 1982; Olsen et al. 1981).

Iron deficiencies are found mainly in high pH (Calcareous soil) soils, although some acidic, sandy soil low in organic matter also may be iron-deficient. Cool, wet weather enhances iron deficiencies. Poorly aerated or compact soil also reduce iron uptake by plants. Uptake of iron decreases with increased soil pH & is adversely affected by high levels of available phosphorus, manganese & zinc in soils. High levels of carbonate, bicarbonate & phosphates in the soil or irrigation water may also lower the availability of iron because low solubility salts are formed. When plants are grown in iron deficient soil, number of varied phenotypes develop which hinder plant growth & reduce economic yield. Severe iron deficiencies cause leaves to turn completely yellow or almost white & then brown as leaves die.

Source of Iron:

Although iron is the fourth most abundant element in the earth's crust, iron deficiency is a common problem for all species, practically. Iron is present in two oxidation states; Fe+++ (Ferric) & Fe++ (Ferrous). In the presence of oxygen, Fe++ is rapidly oxidized to Fe+++, which is poorly soluble in water & which precipitates as oxides of iron. Most soils of our country contain relatively more amount of iron. It is fairly present in form of its oxides giving red or brown colour to the soil. In well-irrigated areas, ferric compounds are predominantly found & in water logged soils, ferrous compounds are formed. The availability of iron to plant increases with acidity and is depressed by phosphorus, manganese & zinc. It is absorbed in Fe+++ (Ferric) & Fe++ (Ferrous) form by the plant root and leaves.

The availability of iron depends on the following factors:

(1) Total quantity of iron present in the soil - The availability of iron depends on the total quantity of iron present in the soil. The oxidized state of iron i.e. hydroxide or hydrous oxide is insoluble.

(2) Soil pH- Iron deficiency of plant

Common iron containing fertilizers are as below-

S. No.	Name of Fertilizers	Typical Fe Content%	Amount of Application (kg/ha.)	
			Soil	Foliar
1	Ferrous Sulphate ($FeSO_4$)	19 - 20	20.0 - 25.0	5.0
2	Ferrous Ammonium Sulphate	14.0	18.3 - 32.0	5.0
3	EDDHA - Fe (Chelated)	5.9 - 7.0	20.0 - 25.0	5.0
4	HEDTA - Fe (Chelated)	2.0	40.0 - 45.0	12.0
5	DTPA - Fe (Chelated)	2.0 - 2.2	40.0 - 45.0	10.0 - 12.0
6	EDTA - Fe (Chelated)	1.8 - 12.0	20.0 - 25.0	5.0 - 7.5

due to high pH is not uncommon. At high pH i.e. in alkali soils, ferrous ion is converted to ferric ion & precipitated as ferric oxide (Fe_2O_3). The availability of iron increases as the pH of the soil decreases.

(3) Aeration - The oxygen is limiting factor in waterlogged condition & the iron availability increases due to reduction of conversion of ferric ion to ferrous ion or more soluble form.

(4) Inorganic reaction – The availability of iron may be reduced in the presence of excess phosphorus, manganese & zinc in soil.

Functions of Iron:

Though iron is not a constituent of chlorophyll, yet it is closely concerned with it & it plays a role of catalyst & electron carrier in respiration. Iron is a constituent of cytochromes, ferredoxin, catalase, peroxidase, ferrochrome, hematin, globoids of aleuronic grains etc. Numbers of horticultural crops like apple, banana, tomato, onion, carrot & spinach contain high percentage of iron.

1. Iron takes part in the synthesis of chlorophyll & imparts dark green colour to plant leaf.
2. It is essential for the synthesis of proteins contained in chloroplast.
3. It has a catalytic role in the activities of several enzymes viz., nitrogenous, peroxidase, proline hydrolase, catalase etc. & it regulates respiration, photosynthesis & reduction of nitrates & sulphates. It also plays an important role in formation & activity of a series of respiratory enzymes.
4. Increase leaf thickness, promotes nutrient uptake and increases the yield.
5. Structural components of phyrin molecules, cytochromes, heme, hematin, ferrochrome, animal & vegetable hemoglobins.

Iron deficiency symptoms:

Lack of mobility accounts for iron deficiency symptoms first appearing on the younger leaves as a yellowing of the leaf blades with the veins & petioles remaining green (Interveinal chlorosis). On some vegetable crops such as carrot, small brown leaf spots may develop on the leaves while the veins & stems remain green. These older fields may have an overall yellow to bronze coloration that gives the field an appearance of early senescence. Severe deficiency of iron may cause leaves to turn completely yellow or almost white & then brown as leaves die. Affected plants will remain small & will not respond well to normal fertilizer treatments. Some visible iron deficiency symptoms are as following.

1. Chlorosis of young leaves & the veins remain green. In severe deficiency, leaves become almost pale white due to loss of chlorophyll.
2. In severe deficient condition,

leaves become dry & papery & may later turn brown & necrotic. Complete leaf fall may occur & shoot can also die.

3. Iron deficiency cause different physiological disorders in fruit plants viz., dieback of young shoot in citrus & litchi, interveinal chlorosis in grape, cherry & pear, yellowing of terminal leaves in mango.
4. In extreme conditions scorching of leaf margins & tips may occur.

Condition causing iron deficiency-

1. Excessive phosphate applications increase iron deficiency.
2. Excessive manganese application reduces iron uptake
3. At early season & in cold temperatures iron uptake will decrease.
4. Excessive liming can reduce iron availability
5. High pH condition also inhibits iron uptake.

High response horticultural crops:

Since iron is an essential element for all horticultural crops, some crops that are more sensitive to iron deficiency, like fruit trees as apple, pear, apricot, cherry, plum, lemon, orange, lime, mandarin, grape & in vegetables like tomato, cucumber & beans. Maximum ornamental & flower plants are responsive for iron deficiency.

Corrective measures of iron deficiency:

A value for available iron of less than 11 ppm in soil is considered low. Optimum value is between 12 & 24 ppm & the management of the soil & fertilization is intended to obtain & maintain these values because normally there is a correlation between the iron available in the soil & that observed in vegetables. Organic matter in the soil exerts a positive effect on the solubility of iron through a reductive effect out of proportion with the amount of iron contained in the biomass. It is known for example that adding organic matter to a soil deficient in available iron exerts a positive effect on the plants. Biological degradation of the organic matter contributes electron & other reducing agents that lower the redox potential of the soil, creating reducing microenvironments (deficient in O_2) in the soil where the concentration of iron available to the plants is increased. Application & maintenance of organic matter in the soil translates to adequate long term availability of iron (Lindsay, 1991). The deficiency of iron can be corrected by application of iron containing fertilizer, organic manure & soil amendments. For long term cases, a process should be adopted to decrease pH of soil, which would increase the iron availability.

1. Apply 20-30 ton ha^{-1} well-decomposed farmyard manure, 20 days before crop sowing / plantation.

2. Iron deficiency symptoms may be corrected by soil application of ferrous sulphate or ferrous ammonium sulphate at the rate of 25-30 kg per hectare or foliar application at the rate of 5.0 kg per hectare.

3. Quick & effective control of iron deficiency in standing crop, apply 2 to 3 foliar sprays @ 0.5 per cent of micronutrient mixture fertilizer foliar grade containing iron.

4. If the soil pH is higher then 8.5, application of iron containing fertilizer through foliar spray.

Time of application-

- For trees the best application is spring before bud burst.
- For citrus, the best application is before summer time
- For horticultural plants & ornamental plants, the best application time at transplanting or at commencing vegetative development.

Physiological disorder in important horticultural crops:

1. Die back of twigs in citrus- Leaves light green or yellow with network of green veins. Leaves become more yellow in cases of acute deficiency. Impaired growth & reduced yield. Die back of twigs visible. Veins remain green in the beginning but in advanced cases they lose colour.

Control measures:

1. Foliar spray of Micronutrient mixture fertilizer - foliar grade containing iron at the rate 0.5 per cent on citrus plant in the month of February- March & repeat it at 15 days interval. Similiar sprays to be repeated in September - October.
2. Application of 20 kg compost per plant at root zone & spray ferrous sulphate.
3. Soil application of ferrous sulphate at the rate 20-25 kg per hectare at pit filling stage.

2. Interveinal chlorosis in grape - Nutritional disorder caused by iron magnesium & zinc deficiency in root zone of the plants. Chlorosis, yellowish spots on leaves, spreading until the leaf become almost white. Lowering of production of new fruit bearing branches, die back of new growth.

Control measures:

1. Foliar application of 0.5 per cent solution of Micronutrient Mixture Fertilizer containing Iron at new growth stage.
2. Grape should not be grown on soils containing more than 0.3 per cent salt.
3. Soil application of ferrous sulphate at the rate of 25 to 30 g per plant during plantation or during January pruning.

3. Die back in Litchi- Leaf yellowing first appears on the younger leaves in Interveinal tissues. Severe iron deficiency cause leaves to turn completely yellow or almost white & then die back of the newly sprouted twigs.

Control measures:

1. Two to three foliar sprays @ 0.5 % of Micronutrient Mixture Fertilizer foliar grade containing iron at 10 to 15 days interval on new vegetative growth stage of the plants.

4. Leaf chlorosis in cherry- Leaves of shoot tips become chlorotic. Detailed vein pattern visible in chlorotic areas. Severe iron deficiency may cause leaf chlorosis & then the leaves die.

Control measures:

1. Proper nutrient management of the fruit orchard by application of well-decomposed organic matter and decrease soil pH to a value of 7.0 by use soil amendments.
2. Foliar application @ 0.5% & Soil application of ferrous sulphate at the rate of 20.0-25.0 kg per hectare at pit filling stage.

5. Die back in Pear- Leaves on the tip become smaller in size, strongly chlorotic or totally bleached. Branches show die back & fruits are highly coloured.

Control measures:

1. Two to three foliar sprays @ 0.5 % of micronutrient mixture fertilizer foliar grade containing iron at 10 to 15 days interval on new vegetative growth stage of the plants.
2. Soil application of ferrous sulphate at the rate of 25 to 30 g per plant during plantation.

6. Leave & shoot tip chlorosis in plum and strawberry- Leaves & shoot tips become chlorotic, the leaves die or branches show die back.

Control measures:

1. Iron deficiency symptoms may be corrected by soil application of ferrous sulphate or ferrous ammonium sulphate at the rate of 25-30 kg per hectare or foliar application at the rate of 5.0 kg per hectare.
2. For quick & effective control of iron deficiency in standing crop, apply 2 to 3 foliar sprays @ 0.5 % of Micronutrient Mixture Fertilizer foliar grade containing iron.

References

1. Chen, Y. and Barak, P. 1982. Iron nutrition of plants in calcareous soils. Adv. Agron. 35: 217-240.
2. Olsen, R.A., Clark, R.B. and Bennett, J.H. 1981. The enhancement of soil fertility by plant roots. Am. Sci. 69:378-384.
3. Robinson, N.J., Procter, C.M., Connolly, E.L. and Guerinot, M.L. 1999. A ferric-chelate reductase for iron uptake from soils. Nature 397:694-697.
4. Theil, E.C., Burton, J.W. and Beard, J. L. 1997. A sustainable solution for dietary iron deficiency through plant biotechnology and breeding to increase seed ferritin control. Eur. J. Clin. Nutr. 51 Suppl. 4: S 28-S 31.
5. Zuang, H. 1982. La fertilization des cultures legumieres. Centre Technique Interprofessional des fruits et Legumes. Patis.

Elemental Sulphur Vs Sulphatic Fertilizers

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As far as consumption of inorganic fertilizers is concerned, I presume, Elemental Sulphur containing fertilizers rank after NPK fertilizers. They are routinely recommended to the farmers with a thrust, as if soil or crop is exhibiting acute Sulphur deficiency which ultimately would be resulted in heavy losses in crop yields. Though the deficiency of Sulphur is rarely noticed, the use of this nutrient is becoming increasingly popular without knowing any scientific facts about this element. Generally, crops are reported to remove 5-10 kg Sulphur/acre.

What are the crops that need Sulphur : Cotton, wheat, maize, sunflower, soybean, sesame, groundnut, sorghum, onion, garlic, cabbage, cauliflower, knol-khol, mustard, tobacco, coconut, some vegetables, tea, etc. Oilseeds, legumes & forage crops have high demand of Sulphur. Thawing cabbage fields emit Hydrogen Sulphide (H_2S) gas. Thus, it is evident that cole crops contain abundant of Sulphur. The typical smell of Cabbage is due to Dimethyl Sulphide. Onion & Garlic also contain Sulphur in appreciable quantities. Their pungency is due to presence of sulphurous compound – Allyl Propyl di Sulphide.

Functions of Sulphur :

1. Sulphur is a component of several amino acids (e.g. Methionine & Cysteine) which are the building blocks of proteins.
2. It is an important constituent of thiamine (vitamin B1), biotin (vitamin H, found in eggs, milk, liver), ferredoxin (aids in Photosynthesis), Acetyl Co-A, glutathione, etc.
3. It promotes nodule formation on the roots & is involved in carbohydrate metabolism.
4. With Nitrogen, it makes protoplasm in plant cells & essential in chlorophyll formation.
5. It increases oil percentage & its recovery & improves baking quality of wheat.

Deficiency Symptoms :

Sulphur Deficiency is often confused with Nitrogen deficiency. The later is seen on older leaves, in senescence (ageing) stage. The leaves dry off, fall down and their size is normal.

In Sulphur deficiency, the young leaves get affected. They turn yellow with pale veins but their size is abnormally reduced. However, they do not dry off and fall down & no necrotic spots are observed on them. The roots & stem become unusually long & develop woodiness. Nodulation in leguminous crops & quality of forage crops is severely affected.

Conditions favorable for Sulphur deficiency:

Heavy leaching losses of Sulphur & hence its deficiency is found mainly in acidic, sandy, coarse textured, cold & very wet soils, soils low in organic matter, soils with excessive nitrogen application, soils in heavy rainfall areas, soils under intensive cultivation & not replaced with sufficient amounts of organic matter & soils far away from industrial activity.

Majority of the soils in India are alkaline & unlike Israel sandy or coarse textured soils are not found allover the country. We receive ample sunshine throughout the year; therefore our soils do not remain cold & wet for prolonged period. The farmers are habituated with adding organic matter in their soils at regular intervals. In addition, plant residues are reported to contain more amounts of Sulphur which is returned back as residues decay in the soil after crop is harvested.

Thiobacillus (bacteria) bring about oxidation of Sulphur in soil organic matter so that it will gradually become available to the plants. Finally, monsoon rains add roughly 4-5 kg Sulphur /acre /year, which is absolutely free of cost.

The availability & uptake of Sulphur gradually increases from pH 4.0 to 6.0 (acidic pH) beyond which there is maximum & steady absorption of Sulphur up to pH 10.0 (very strongly alkaline pH). Similarly temperature chart depicts that there is increasing uptake of Sulphur from 16 to 24 °C & steady uptake in temperature range 24 to 38 °C.

Therefore we seldom notice Sulphur deficiency in the fields.

Difference between Elemental Sulphur & Sulphatic Fertilizers:

Just like Nitrate form (NO_3) is reduced before it can be used to form proteins, Sulphate form must also be reduced to become a part of Sulphur containing organic compounds in the plant. Sulphur exists in different chemical forms in nature but roots can absorb it in Sulphate (SO_4) form alone, as this is the only form completely soluble in water. Then it goes into the production of Sulphur containing amino acids like Cysteine, Methionine, etc.

This obviously means that all forms of Sulphur in soil must be converted to SO_4 form in order to get utilized by plants. The Sulphate ions move freely with soil moisture. In other words SO_4 form is moderately susceptible to leaching losses, however, not to the extent of Nitrate Nitrogen (NO_3) As a result, Sulphate levels frequently increase with increasing depth in the soil profile. For this reason, small amount of Sulphatic fertilizers applied in a starter fertilizer is sometimes all that is needed to get young roots off to a fast start, quickly growing down through the soil profile to greater depths where supplies of SO_4 are more plentiful.

Elemental Sulphur (90% Sulphur in Elemental from & 10% Bentonite clay) is inert & water insoluble, hence totally unavailable to plants as they simply cannot absorb it through the root system. Once incorporated in the soil it is to be oxidized to the plant available SO_4 form. The rate at which this conversion takes place is the determining factor regarding its effectiveness as a fertilizer source of Sulphur. It is dependent on time (period), temperature, pH, moisture, etc. The finer the particle size of Sulphur, the quicker will be the rate of oxidation, hence absorption. The residual effect of Elemental Sulphur is reported to exist in soil up to next 6 seasons. In other words it generally requires 3 years for elemental Sulphur to become fully available for a crop.

The Elemental Sulphur sources are highly acidifying while Sulphate sources can be either acidic or neutral in reaction.

Some Sulphatic Fertilizers with their Sulphur Content :

Gypsum (14-20%)
Ammonium Sulphate (24%)
Ammonium Sulphate Phosphate (15%)
Single Super Phosphate (12%)
Sulphate of Potash (18%)
Potassium-Magnesium Sulphate (20%)
Potassium Schoenite (15%)
Magnesium Sulphate (12%)
Ferrous Sulphate (10.5%)
Manganese Sulphate (17%)
Zinc Sulphate Monohydrate (15%)
Zinc Sulphate Heptahydrate (10%)
Copper Sulphate (12%)

Though none of the fertilizer from above list is advocated for fulfilling Sulphur needs of a crop, however, applying any of them in recommended quantity will also add appreciable quantities of Sulphur in the soil. Therefore, Sulphatic fertilizers usually give quick results in lesser time while elemental Sulphur containing fertilizers are less likely to produce desired results of their use on the standing crop.

The only advantage of elemental Sulphur containing fertilizers over Sulphatic fertilizers is their long term residual effect in the soil. However, it is of little consequence in the overall Sulphur nutrition of a crop.