FACT SHEET

March 2022

IRON

1. INTRODUCTION

Of all the elements plants derive from the soil, iron (Fe) is the most abundant. Yet, as far as plant nutrition is concerned, it is classified as a micronutrient, or trace element, as it is only required in small amounts. Consequently, total soil iron is always greatly in excess of crop requirements. Any problem of iron supply to crops is therefore one of availability in the soil.

2. IRON IN THE SOIL

Iron makes up about 5% of the earth's crust, being ranked fourth in abundance after oxygen, silicon and aluminium. Total soil iron concentrations are often around 2.5%. Iron is present in primary minerals; in the crystal lattices of silicate clays; and in highly weathered soils, as hydrous oxides in the clay fraction. Ionic forms, which will be present in the soil solution or adsorbed onto soil particles, include Fe (II) and Fe (III). Of these, it is Fe (II) which is taken up by plant roots. Fe (II) is also referred to as ferrous iron (Fe^{2+}), Fe (III) as ferric iron (Fe^{3+}).

Deficiencies of iron generally occur as a result of availability problems rather than from low total iron levels in the soil, as the content of soluble (available) iron is extremely low in comparison with the total iron content. The solubility of the hydrous iron oxides determines how much iron will be present in the soil solution and available for plant uptake.

Factors that affect the availability of iron in the soil include:

pH

In common with copper, manganese and zinc, iron deficiency is most likely to occur on alkaline (high pH) soils. As soil pH increases, the ionic forms, e.g. Fe (II), are changed to less soluble or insoluble hydroxides or oxides.

Bicarbonate (HCO_3^-), which is found in higher concentrations in calcareous (alkaline or high pH) soils, and following the application of lime (calcium carbonate), can also has a direct physiological effect on plants, by immobilising iron and preventing its translocation to young leaves. "Lime induced chlorosis" (iron deficiency) is now considered to be more attributable to the effect bicarbonate has on movement of iron within the plant, than to the effect lime has in reducing the availability of iron in the soil.

Waterlogging

In **acid** soils under water - logged conditions, anaerobic bacteria reduce iron from Fe (III) to Fe (II), i.e. from the ferric to the ferrous form. The resultant increase in the concentration of Fe (II), the form of iron taken up by plant roots, may result in iron toxicity, e.g. in paddy rice.

This situation is reversed on **alkaline** or calcareous soils, where temporary iron deficiency may occur following irrigation, e.g. the heavy clay soils used for cotton production in northern NSW and Queensland. The reduction of Fe (III) to Fe (II), which occurs in acid soils when water - logged, is depressed where the soil pH_w is above 7. In addition, bicarbonate can accumulate in such soils when water - logged, particularly if the soil is poorly structured.

Phosphorus

Phosphorus applied as fertiliser can react with iron in the soil to form insoluble iron phosphate. In **calcareous** (high pH) soils, where iron availability is low, this may result in iron deficiency. In **acid** soils, where iron is more available, phosphorus will be ‘fixed’. This is particularly important on red volcanic soils, necessitating the need to apply phosphorus at higher rates than on most other soil types.

Interactions with Other Elements

High concentrations of other cations, e.g. copper, manganese, zinc, calcium, magnesium and potassium may interfere with the uptake of iron due to competitive effects at the root surface. In particular, high manganese (often associated with low pH) may induce iron deficiency on acid soils, where this would not normally be expected, e.g. in pineapples.

Organic Matter

Iron can be immobilised in complexes with organic matter in soils. The iron held by organic matter becomes available as the organic matter decomposes. Iron may also react with organic acids to form organic complexes or chelates. As such, iron is less subject to fixation, and remains available for plant uptake at soil pH levels where inorganic iron is rendered insoluble. However, these naturally occurring chelating agents are not always abundant or stable enough to maintain plant available iron at the level required for normal plant growth.

3. IRON IN PLANTS

3.1 Uptake of Iron

Iron is taken up by plants as Fe (II). Uptake occurs at the root tips, so there is a restricted zone between the plant and the soil from which uptake can occur. Anything that affects the health of the root tips can affect iron nutrition. For example, calcium deficiency affects the growing points of roots and stems, and may therefore be associated with iron deficiency.

Iron is essential for the formation of chlorophyll, the green pigment or colouring found in leaves. It is not readily mobile within plants, i.e. it is not easily moved from old to young tissue

3.2 Iron Deficiency

Iron deficiency is most likely to occur in:

- recently limed soils;
- alkaline soils where levels of plant available iron are low, particularly if water- logged;
- acid soils (even though iron is most available at low pH) where excessively high levels of soluble manganese, zinc, or copper depress the uptake of iron by plants;
- sandy soils low in total iron;
- peat and muck soils where organic matter ties up iron;
- situations where normal root development is impaired, e.g. root damage from disease, insects or nematodes; calcium deficiency, and low soil temperatures;
- hydroponic crops, e.g. strawberries;
- potted plants.

The most notable symptom of iron deficiency is chlorosis or yellowing between the veins of the youngest leaves, while older leaves remain green. This allows iron deficiency to be distinguished from magnesium deficiency, which is also characterised by a failure in chlorophyll production.

There is usually a sharp distinction between the yellow chlorotic tissue and the green veins (distinguishing iron deficiency from zinc and manganese deficiencies in which there is a gradual colour change from the green veins to the chlorotic interveinal tissue). In severe cases, the yellowing runs into the veins and the whole leaf turns yellow or even white.

3.3 Iron Toxicity

Toxicity is most likely to occur in acid waterlogged soils. In rice, the first leaf symptoms are tiny brown spots which develop into a uniform brown colour, a condition known as “bronzing”.

4. CRITICAL LEVELS OF IRON

4.1 Soil Analysis

Nutrient Advantage Laboratory determines plant-available iron concentrations in soils by extraction with DTPA (a chelating agent). Soils that contain less than 2 mg/kg Fe are considered to be low in available iron. In some crops, deficiencies may occur or iron responses may be obtained at these levels. Available iron levels can fluctuate with seasonal conditions, e.g. the degree of waterlogging.

4.2 Plant Tissue Analysis

The iron content of green plant tissues is generally around 100 mg/kg Fe on a dry weight basis. In general, legumes have a higher iron requirement than grasses. Iron concentrations in leaf tissue below 50 mg/kg Fe often indicate a deficiency.

In rice, toxicity may occur when iron concentrations are in the range of 300-1000 mg/kg Fe. High iron (and aluminium) concentrations may also indicate that the leaf surfaces have been contaminated with soil or dust. If this occurs, much of the iron will be on, rather than in the plant, and therefore not affecting plant growth

5. IRON FERTILISERS

Incitec Pivot Fertilisers markets a granular **iron oxysulfate** product (Incitec Pivot Iron Granules). Incitec Pivot Iron Granules contains 25 % Fe, in soluble (sulfate) and insoluble (oxide) forms. Iron Granules can only be applied dry to the soil. It cannot be applied in solution. Iron Granules is primarily used in lawns and turf, and is available as a blend ingredient ex some Incitec Pivot blending sites. Other commonly used iron fertilisers are **iron sulfate** (19.7 % Fe) and **iron chelate**.

Both iron sulfate and iron chelate are soluble in water and are normally applied as sprays, either to the soil or foliage. With the exception of lawns and turf, it is generally recommended that iron be applied as a foliar spray where it is required. Chelates have wider compatibility with other fertilisers when applied in solution (dissolved in water). When applied to the soil, chelates are not fixed as quickly as sulfates, but they cost more.

6. CORRECTING IRON DEFICENCY

6.1 Soil Application

Soil applications are generally not recommended, and may be ineffective, particularly if factors such as waterlogging in alkaline soils, or high manganese in acid soils, are restricting uptake of iron from the soil or its translocation in plants. Foliar applications are usually much more effective, and give quicker responses.

Iron deficiency is usually a result or it being unavailable in the soil rather than not being present in an adequate amount. Therefore, iron applied to soils in which iron deficiency occurs in crops is likely to be fixed quickly, particularly on alkaline (high pH) soils.

Soil applications of iron fertiliser are usually confined to lawns and turf. The fertiliser is broadcast applied without mechanical incorporation. The roots of lawn grass species are found close to the soil surface, and have a better chance of utilising the iron before it is fixed in the soil, compared to situations where deeper rooted plant species are grown, or the fertiliser is incorporated into the soil. Iron may need to be applied at high rates to allow for fixation.

Suggested application rates for Iron Granules (iron oxysulfate) or Iron Sulfate on acid soils are 40 kg/ha on heavy clay soils and 2.5 to 10 kg/ha on light (sandy) soils. Such applications may not be effective in all situations, and the benefits may be short lived, e.g. for no more than a season. Considerably higher rates are recommended in some instances, ten or more times these rates, e.g. 500 kg/ha, although the economics of such use must be questioned. Band applications are likely to be more effective than broadcast applications.

If iron is to be applied to alkaline (high pH) soils, iron chelate should be used in preference to iron sulfate. Iron fertiliser is often applied to lawns, playing fields and turf. A typical application rate for Iron Granules or Iron Sulfate is 20 kg/ha (200 g/100 m^2). In strawberries, apply Iron Granules or Iron Sulfate at 1 – 2 g/m of row.

6.2 Foliar Application

Foliar sprays are the preferred way to apply iron in most crops. Iron sprays can burn leaves, and specific crop advice should be sought before use. The following guidelines are for Iron Sulfate. They should only be used if more specific district and crop advice is not available from the fertiliser supplier and/or local advisers.

Iron Sulfate is also known as Ferrous Sulfate. It has the chemical formula of $FeSO_4.7H_2O$, and contains 19.7% Fe. As iron is immobile in plants, and does not move readily from old to young leaves, the effect of foliar sprays is short lived. In perennial crops, three or four repeat sprays may be required, commencing with the onset of the vegetative period. In annual field crops, foliar applications should commence when there is sufficient foliage to absorb the spray and be repeated at 2 to 3 week intervals.

Typically, up to and about 1 kg/ha of iron sulfate is applied per application.

Grain 1 kg/100 L (1 % w/v), at up to 100 L/ha.

Horticulture 100 g/100 L (0.1 % w/v), at up to 1,000 L/ha. Reduce concentration accordingly at higher spray volumes, eg. in tree crops. In sensitive crops such as strawberry, the spray concentration should not exceed 50 g/100 L. In vegetables and tree crops, 3 or 4 repeat sprays may be required during the growing season. Avoid spraying while crops are flowering. Avoid spraying tree crops when the main fruit crop is on the tree. Do not spray peaches or nectarines after the fruit have reached approximately one-tenth of their final size.

Add Urea (1 kg/100 L in field crops, 500 g/100 L in vegetables, 100 g/100 L in tree crops); plus a wetting agent at label-recommended rates. Urea helps promote the absorption and uptake of other nutrients by plant leaves.

Do not exceed the above iron sulfate concentrations/rates, as plants are easily scorched by iron sprays.

Iron chelate, which is less likely to burn plant foliage than iron sulfate, can be used as an alternative. If Iron Chelates is used, advice should be sought from the supplier on appropriate application rates. While chelates have a lower iron content, similar product application rates to those used for iron sulfate are often recommended.

This advice should be read in conjunction with the Incitec Pivot Agritopic on "Foliar Fertilisers". It contains further information on fertiliser burn, its management, and related topics.

6.3 Iron Sulfate Compatibility in Solution

Iron sulfate is compatible with urea, ammonium nitrate, potassium fertilisers, magnesium sulfate and metallic trace elements. Do not mix with phosphorus, calcium or boron fertilisers. Mixing iron sulfate with chelated trace elements is not recommended. Fertiliser solutions should be prepared just prior to use, and not allowed to stand for an extended period, to minimise sediment formation and settling in tanks.

WARNING

The information contained in this publication is for use as a guide only. The use of fertilisers is not the only factor involved in producing a top yielding pasture or crop. Local soil, climatic and other conditions should also be taken into account, as these could affect pasture or crop responses to applied fertiliser.

Before using fertiliser seek appropriate agronomic advice. Fertiliser may burn and/or damage plant roots or foliage.

Foliar burn to the leaves, fruit or other plant parts is most likely to occur when different products are mixed and sprayed together, the water is of poor quality, or the spray is applied under hot dry conditions, eg. in the heat of the day.

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