AGRITOPIC

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MANGANESE

1. INTRODUCTION

Manganese (Mn) is classified as a micronutrient or trace element. Plant requirements for micronutrients is relatively small amounts i.e., g/ha. Other micronutrients required by plants are boron, copper, iron, zinc and molybdenum. Deficiencies are more likely to occur on alkaline soils. Toxicity can occur occurs on very acid soils.

2. MANGANESE IN THE SOIL

The total amount of manganese in soils varies from less than 0.1% up to 13% in some volcanic soils. Typically, it is around 2,500 mg/kg (0.25%) and is normally in the range of 200–10,000 mg/kg Mn (0.02 - 1%).

Manganese is the eleventh most abundant element forming the Earth's crust. Out of the micronutrients, it ranks second to iron in terms of abundance. Its concentration typically exceeds that of macronutrients such as phosphorus and sulphur and nitrogen. Consequently, when plant deficiency occurs on soils containing adequate/ high total manganese, it is because most of the Mn present is in forms that are not plant available. Deficiencies also occur on soils containing low total manganese.

In plant nutrition, the most important soil fractions of manganese are the divalent manganese ion (Mn^{2+}) and the manganese oxides in which manganese is present in trivalent or tetravalent form. Like other cations, Mn^{2+} is adsorbed onto clay minerals and organic matter.

The mobility of manganese in soils depends on soil texture. Sandy soils with low cation exchange capacity (CEC) (e.g., acid podsolic soils) can experience leaching losses of manganese but, heavy clay soils with high CEC are unaffected. Factors which affect the availability of manganese in the soil include:

<u>Soil pH</u>

Soil Mn^{2+} concentrations decrease 100-fold for each unit increase in pH. At high soil pH_{water} (over 7.5), manganese availability may not be adequate to meet plant demand. At low pH_{water} levels (less than 5.5), manganese becomes very soluble and manganese toxicity may occur. High manganese concentrations may also depress the uptake of other nutrients e.g., iron.

<u>Soil Organic Matter</u>

Soils with high pH and high organic matter are prone to manganese deficiency. As soil pH increases, complexes between divalent manganese ions and organic matter form, reducing the amount of plant available Mn^{2+}.

Cultivation will increase the availability of manganese in the soil by accelerating the decomposition of soil organic matter.

Soil Moisture

Under water-logged conditions, manganese oxide can be reduced by soil bacteria to Mn^{2+}. This may cause soil manganese levels to become potentially toxic. Under very dry conditions, insoluble dehydrated manganese salts can form in the soil which reduces the availability of manganese.

3. MANGANESE IN THE PLANT

3.1 Uptake

Plants take up manganese as Mn^{2+} from the soil solution. High concentrations of other cations in the soil solution e.g., calcium, zinc, magnesium and ammonium can reduce manganese uptake by plants. Conversely, manganese may depress the uptake of other cations such as iron e.g., in pineapples and ginger. Once taken up and incorporated into plant tissue, manganese is relatively immobile in the plant i.e., it is not readily relocated from old to young tissue. Hence, deficiency symptoms first appear in young leaves.

3.2 Deficiency Symptoms

Manganese deficiency symptoms closely resemble those of magnesium, as in both cases interveinal chlorosis (yellowing) occurs in the leaves. However, magnesium deficiency effects older leaves first.

In tree crops, deficiency symptoms usually appear on recently matured leaves in early summer growth, as opposed to very young leaves in the case of iron deficiency or, old leaves in the case of magnesium and potassium deficiency. Leaf shape and size, and shoot length are usually normal, with symptoms developing worse on the southern or shady side of trees (in the southern hemisphere).

Manganese deficiency symptoms in broad-leaf plants (dicotyledons) occur as small yellow spots on the younger leaves, which turn brown or black. The abscission of developing leaves commonly occurs which reduces flower formation.

In cereals and grasses, greyish or brownish spots and streaks occur in the middle or basal parts of younger leaves. These necrotic spots may merge into a band across the leaf isolating the still green end portion of the leaf.

The incidence and severity of manganese deficiency appears to depend on seasonal conditions. The deficiency is often worse under cold, wet conditions; possibly because of a reduction in root metabolic activity affecting manganese uptake.

3.3 Toxicity Symptoms

Manganese toxicity is characterised by raised interveinal areas giving a puckered appearance, red, brown or black spotting of the older leaves and an uneven distribution of chlorophyll. If the toxicity continues, the plants will wilt and die prematurely. Plants particularly susceptible to manganese toxicity are lucerne, cabbage, cauliflower, cereals, clover, pineapple, potato and tomato.

Manganese toxicity generally occurs on poorly drained soils high in manganese or on strongly acidic soils. It is usually associated with other acid soil infertility problems such as aluminium toxicity and deficiencies of calcium, magnesium and molybdenum.

4. CRITICAL LEVELS

4.1 Soil Analysis

Plant available manganese is measured by the Incitec Pivot Laboratory using the DTPA extraction method. Most plant species do not show deficiency or toxicity symptoms within a range of 4-50 mg/kg Mn. Some legume crops may display toxicity symptoms if the manganese level in the soil rises above 30 mg/kg Mn, especially if waterlogged conditions prevail.

Soil manganese levels can fluctuate quite markedly into and out of the excessive range depending on biological activity in the soil and seasonal conditions. Biological activity is likely to be reduced during prolonged dry periods. Temporary excessive levels of manganese may occur if the soil becomes waterlogged.

Plant tissue analysis is recommended over soil analysis to confirm suspected cases of manganese deficiency or toxicity.

4.2 Plant Tissue Analysis

Critical values are highly variable between different crops and even vary between varieties. Plant growth stage and the plant part sampled are factors which influence plant tissue analysis results.

The critical deficiency level for most plant species is below 15 to 25 mg/kg Mn in the dry matter of upper plant parts. Normal leaves usually contain between 20 and 500 mg/kg Mn on a dry matter basis. Toxicity symptoms may become evident in the vicinity of 500 mg/kg Mn in the dry matter.

5. MANGANESE FERTILISERS

Various manganese fertilisers are available. Some of the more commonly used products are:

Manganese Sulfate

Coarse granular grades for dry application to the soil and soluble fine grades for application in solution e.g., foliar sprays are available. The manganese concentration will depend on the level of hydration:

- Manganese Sulfate Monohydrate ($MnSO_4.H_2O$) contains 31-32.5% Mn.
- Manganese Sulfate Tetrahydrate ($MnSO_4.4H_2O$) contains 25% Mn.
- Manganese Sulfate Heptahydrate ($MnSO_4.7H_2O$) contains 20% Mn.

Incitec Pivot Fertilisers uses a granular grade of Manganese Sulfate Monohydrate (**Manganese Sulfate Granular**) containing 31% Mn as a blend ingredient at some Distribution Centres. This product, which is also offered for straight sale, is primarily intended for use in South Australia in planting fertilisers in crops grown on alkaline calcareous soils.

Manganese Oxysulfate

These products are suitable for dry application to the soil only as they are not fully water-soluble.

Manganese Chelate

Manganese chelate can be applied in solution either to the soil or as a foliar spray. The chelated forms are less subject to soil fixation than sulfate forms but are more costly.

6. CORRECTION OF MANGANESE DEFICIENCY

6.1 Soil

Soil-applied manganese can be rapidly converted to plant-unavailable forms and is therefore not commonly recommended. Soil applications are used at planting in grain crops grown on calcareous soils in South Australia. Typical application rates of manganese sulfate monohydrate are 10-20 kg/ha. Banding manganese fertiliser with the seed at planting reduces fixation and provides early root access for plant uptake.

Blending manganese with fertilisers that produce an acid reaction around the granules whilst dissolving in the soil, such as MAP, may further enhance its effectiveness. If manganese is broadcast, higher rates will be required as the manganese is exposed to more fixation sites in the soil.

A typical application rate for a broadcast situation of manganese sulfate monohydrate is 50 kg/ha. Up to 100 kg/ha may be required in some situations. In crops other than grain, it is recommended that manganese be applied as foliar sprays where practicable rather than to the soil.

6.2 Foliar

Foliar sprays are the preferred way to apply manganese in most crops. They are normally more effective than soil applications. In horticultural crops (fruit and vegetables), manganese can be conveniently applied to the foliage in combination with routine crop protection sprays. Manganese sulfate concentrations of up to 0.5% w/v (500 g/100 L) are used in vegetables, while in tree crops and vines, 0.2% w/v (200 g/100 L) sprays are generally applied.

In tree crops, foliar applications annually in the spring targeting good coverage of newly developed leaves is usually sufficient for maintenance. In cases of severe deficiency, more than one spray may be necessary.

Typical foliar application rates for soluble grades of manganese sulfate monohydrate are shown in the following table. These may be used if more specific district and crop advice is not available.

Suggested Spray Programs for Foliar Applications of Manganese Sulfate Monohydrate

Crop	**Concentration**		**Comments**
	/100L	**% W/V**	
Grain	1 kg	1%	Apply at 3 to 5 weeks after emergence. Higher rates are required on highly calcareous soils. In South Australia, up to 3.5 kg/ha is recommended on such soils 6 to 8 and 12 to 14 weeks after seeding. Lupins on manganese-deficient soils require a foliar spray at pod-set on the primary axis to prevent split and poorly filled seed.
Vegetables	500 g	0.5%	Apply a single spray at 4 to 6 leaf stage. Alternatively, apply 3 to 4 sprays at 2-week intervals at a reduced concentration i.e., 100 g/100L (0.1% w/v).
Grape	200 g	0.2%	Apply when new shoots are 15 to 25 cm long.
Pome Fruit (apples & pears)	200 g	0.2%	Apply at the calyx stage.
Other tree crops	100 g	0.1%	Apply to new growth e.g., spring flush when leaves are one-half to two-thirds full 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 uptake of foliar applied nutrients.

Nutrient sprays may burn plant foliage. Please refer to the Incitec Pivot Agritopic on "Foliar Fertilisers" for further information on this and related topics.

Check the label of crop protectants for advice on compatibility before adding manganese to the spray tank.

7. FUNGICIDE SPRAYS

The use of manganese-based fungicides such as mancozeb e.g., Dithane M45, will often supply sufficient manganese to correct deficiency. Yield responses over and above the expected fungicide effect where manganese-based fungicides are used are most probably due to a response to manganese (and/ or zinc in mancozeb).

8. COMPATIBILITY OF MANGANESE SULFATE IN SOLUTION

Manganese sulfate is compatible with urea, ammonium nitrate, potassium fertilisers, magnesium sulfate and other metallic trace elements. It is generally recommended that metallic sulfates such as manganese sulfate not be mixed with chelated trace elements.

Manganese sulfate should not be mixed with phosphorus, calcium or boron fertiliser as precipitates will form.

9. CORRECTION OF MANGANESE TOXICITY

Where a manganese toxicity is confirmed by soil and plant tissue analysis, liming to a pH_{water} of 6.5 to 7.0 is recommended. In annual crops, lime or dolomite should be applied 2 to 3 months before planting and be incorporated into the soil.

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.

Because climatic and soil conditions, application methods, irrigation and agricultural practices are beyond the control of Incitec Pivot Limited and cannot be foreseen, Incitec

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