Chapter 4. Manganese deficiency

SOYBEAN (*Glycine max* L.)

Plate 59. Manganese deficiency of soybean. The leaves show interveinal chlorosis. The veins remain green.

Taiwan: Subtropical climate

Photo by Mr. Ching-Hsee Lin, Taiwan ROC

Description of symptoms

Manganese deficiency in soybean is widespread in eastern Taiwan. It first takes the form of a lightening of the green color of the leaves, which gradually turn yellow.

Soil conditions likely to produce this deficiency

The black calcareous soils where this condition is common are considered quite fertile, but the presence of calcium carbonate and the alkaline pH may cause manganese deficiency in soybean

How to correct manganese deficiency of soybean

A common remedial measure is to apply a foliar spray of 0.50% manganese sulfate ($MnSO_4$) solution once every week. The pH of the soil, and any nutrient solution used, should be adjusted to 5.5-6.5 by apply ammonium sulfate. Alternatively, 200-400 kg /ha of manganese sulfate can be applied to the soil, and then 2 mt/ha of sulfur.

Information from Dr. Zueng-Sang Chen, National Taiwan University

TOMATO (*Lycopersicon esculentum* mill.)

Plate 60

Plate 61

Plate 62

Plate 60. Tomato leaves show interveinal chlorosis. The veins remain green.
Plate 61. Interveinal chlorosis is seen in the younger leaves. A normal leaf is shown on the right.
Plate 62. The petioles of the tomato flower are cut.

Korea: Temperate climate

Description of symptoms

All tomato plants shown in the Plates were grown by hydroponic culture in a plastic greenhouse. However, the symptoms were the same as those of manganese deficiency of crops grown in field soil. Manganese deficiency in widespread in tomato plants. It manifests itself first as a lightening of the green color in the interveinal area of the leaves, which gradually turns to yellow.

How to correct manganese deficiency of tomato

The deficiency can be corrected by applying a foliar spray of 0.3% manganese sulfate ($MnSO_4$) solution. The pH of the soil, and any nutrient solution used, should be adjusted to 5.5-6.5.

Photos and information from Dr. Byoung-Choon Jang, National Institute of Agricultural Science and Technology, Korea

EGGPLANT (*Solanum melongena* L.)

Plate 63

Plate 64

Plate 63. Field of eggplant (var. Ryoma) with manganese deficiency

Plate 64. Damaged eggplant

Plate 65

Plate 65. Leaves of normal plants (left) and leaves damaged by manganese deficiency (right). The interveinal area of the leaves is brown in color, although the veins remain green.

Japan: Temperate climate

Soil conditions likely to produce manganese deficiency

Manganese deficiency is common in soils with a high pH, and in highly oxidized soil conditions, (dry soil with a low level of organic matter). In Japan, this condition is often seen in eggplant cultivated in old paddy fields, from which the manganese has been leached. It is also found in soils where the parent material has a high lime content

Diagnosis by soil analysis

The critical level of exchangeable manganese in the soil is 2.3 mg/kg, using 1M ammonium acetate (pH 7.0) extraction.

Diagnosis by plant analysis

The upper leaves should be tested, since it is these that tend to show the most marked symptoms.

Interaction with other elements

High levels of calcium, copper, iron, zinc and phosphate may prevent manganese absorption and transportation. Calcium in particular has a strong effect in preventing manganese absorption.

How to correct manganese deficiency in eggplant

The pH of the soil should be lowered, and the water-holding capacity improved, by applying organic matter to increase the humus content of the soil.

Fertilizer applications may include the application of manganese materials to the soil, or a foliar spray of manganese solution

Photos and information from Mr. Mitsuharu Nakashima, Eisai Seikaken Co. Ltd., Japan

WATERMELON (*Citrullus vulgaris* Battich)

Plate 66

Plate 67

Plate 68

Mn applied Control (no Mn)

Plate 69

Mn applied Control (no Mn)

Plate 66. Watermelon in greenhouse in Hokkaido, Japan, with manganese deficiency. The symptoms are seen on all plants. Usually the interveinal area of 4-8 leaves turns yellow before the plants begin to flower.

Plate 67. Typical symptoms of manganese deficiency on watermelon leaves. Interveinal chlorosis and white spots appear after the plants begin bearing fruit.

Plate 68. Deficiency symptoms spread from lower leaves to upper ones over time. Deficient leaves are chlorotic compared to normal ones.

Plate 69. Effect of manganese application on the growth of water melon. Normal leaves from plants amended with manganese carbonate at a rate of 500kg/ha are on the left. Leaves from control plants with no applied manganese are on the right.

Japan: Temperate climate

Soil conditions likely to result in manganese deficiency

The condition is usually found in soils with a high pH, and a level of easily reductive manganese of less than 100 mg Mn/kg (extracted by 2% hydroquinone + 1M ammonium acetate).

Diagnosis by soil analysis

Manganese content in soil (mg/kg)

	Easily reductive Mn (2% hydroquinone+1M ammonium acetate*)	Exchangeable Mn (1M ammonium acetate*)
Normal	192	1.3
Deficient	34	0.2

*Neutral 1M-ammonium acetate

Diagnosis by plant analysis

Manganese content in leaves at harvest time (mg/kg)

	Mn
Normal	53
Deficient	26

How to correct manganese deficiency of watermelon

The condition can be remedied by applying manganese carbonate or manganese sulfate at a rate of 500 kg/ha, or manganese oxide (MnO) at a rate of 200 kg/ha, as a basal application.

Photos and information from Dr. Susumu Eguchi, Ferro Enamels (Japan) Ltd.

GRAPE (*Vitis vinifera* L. var. Italia)

Plate 70. The leaves of grape suffering from manganese deficiency show interveinal chlorosis, while the veins remain green. The concentration of manganese in the leaf is only 10 mg Mn/kg.

Taiwan: Subtropical climate

Photo by Dr. Su-San Chang, Taiwan ROC

Description of symptom

The leaves of grapes show interveinal chlorosis, while the veins remain green.

How to correct the deficiency

The deficiency can be corrected by applying a foliar spray of 0.3% magnesium sulfate ($MnSO_4$) solution. The pH of the soil and nutrient should be adjusted to 5.5-6.5.

PASSIONFRUIT (*Passiflora edulis* Sims)

Plate 71

Plate 72

Plate 73

Plate 71 and Plate 72. Leaves of passionfruit suffering from manganese deficiency

Plate 73. Passionfruit orchard showing manganese deficiency

Taiwan: Subtropical climate

Photos by Mr. Wei-Tin Huang, Taiwan ROC

Description of symptoms

Manganese deficiency in passionfruit plants first manifests itself in a lightening of the green color in the interveinal areas of the leaves, which gradually changes to yellow (interveinal chlorosis). The veins of the leaves remain green.

Soil and climatic conditions likely to produce manganese deficiency

Manganese deficiency is widespread in calcareous soils. It is sometimes also found in soil which contains a high level of organic matter. Ferrous manganese may be oxidized into manganese oxide, which is not available to plants, in alkaline calcareous soils, or in sandy soils with good aeration. High levels of phosphate, calcium, iron, and zinc in the soil may hinder the uptake of manganese by crops, leading to manganese deficiency.

Diagnosis by plant analysis

Levels of manganese in a normal passionfruit leaf range from 25 to 200 mg/kg. Levels lower than 25 mg/kg are likely to result in manganese deficiency. The critical concentration of manganese in the fruit is 10-20 mg/kg dry weight.

How to correct manganese deficiency of passionfruit

The most common way to correct manganese deficiency of passionfruit is to apply a foliar spray of 0.3% manganese sulfate ($MnSO_4$) solution once every week. The pH of the soil and any nutrient solution used should be adjusted to 5.5-6.5.

Information from Dr. Zueng-Sang Chen, National Taiwan University

CITRUS (*Citrus sinensis* Osbeck)

Plate 74

Plate 75

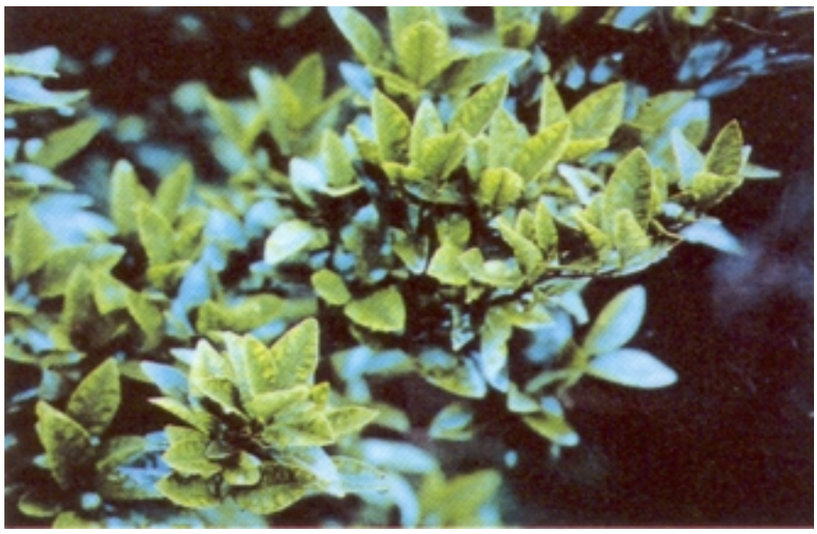

Plate 74. The leaves of citrus (*Citrus sinensis* Osbeck var. Liucheng) showing interveinal chlorosis, although the veins remain green. The concentration of manganese (Mn) in the leaves is only 10 mg Mn/kg.

Plate 75. Leaves of tree suffering from manganese deficiency. The younger leaves show interveinal chlorosis. The concentration of manganese in the leaf is less than 25 mg Mn/kg.

Plate 74 by Mr. Ching-Hsee Lin, Taiwan ROC
Plate 75 by Dr. Su-San Chang, Taiwan ROC

Plate 76. Citrus tree (*Citrus sinensis* Osbeck var. Mato-Wentan) with manganese deficiency. Symptoms of interveinal chlorosis can be seen in the younger leaves. The concentration of manganese in the leaves is only 13 mg Mn/kg.

Plate 76 by Mr. Wei-Ting Huang, Taiwan ROC

Taiwan ROC: subtropical climate

Description of symptoms

Manganese deficiency of citrus is fairly common in Taiwan. It first appears as a lightening of the green color of leaves, which gradually turn yellow.

Soil conditions likely to result in manganese deficiency

Most of the black calcareous soils in which these citrus trees are growing are considered quite fertile. However, the presence of calcium carbonate and the alkaline pH may cause manganese deficiency.

How to correct manganese deficiency

The deficiency is corrected by spraying the foliage with 0.25-0.50% manganese sulfate solution, once every week. The soil pH, and the pH of any nutrient solution used, should be adjusted to 5.5 - 6.5 by applying ammonium sulfate. An alternative to the foliar spray is the application of 200-400 kg/ha of manganese sulfate to the soil.

WAX APPLE (*Syzygium samarangense* Merr. et Perry)

Plate 77. Leaves of wax apple tree suffering from manganese deficiency, showing interveinal chlorosis. The concentration of manganese in the leaves is only 15 mg Mn/kg

Photo by Ms. Chen Fu-Ying, Taiwan ROC

Taiwan: Subtropical climate

Description of symptoms

The leaves of wax apple trees suffering from manganese deficiency show interveinal chlorosis. However, the veins remain green.

Soil and climatic conditions likely to result in manganese deficiency

Most of the black calcareous soils where this condition is found are considered quite fertile. However, the presence of calcium carbonate and the alkaline pH may cause manganese deficiency.

How to correct manganese deficiency of wax apple

A foliar spray of 0.25-0.50% ($MnSO_4$) manganese sulfate solution should be applied once every week. The pH of the soil should be adjusted to 5.5-6.5 by applying ammonium sulfate. Alternatively, 200-400 kg /ha of manganese sulfate can be applied to the soil.

Information from Dr. Zueng-Sang Chen, National Taiwan University

PEAR (*Pyrus serotina*, Rehder)

Plate 78

Plate 79

Plate 80

Plate 78. Pear tree with manganese deficiency at the end of September (autumn). The whole leaf begins to turn pale in May (spring), while inter-veinal chlorosis appears in June.

Plate 79. Distinct interveinal chlorosis in leaves damaged by manganese deficiency

Plate 80. The leaf deficient in manganese is the same size as a normal one. Even if the deficiency is treated, the affected leaf retains the symptoms until it falls.

Japan: Temperate climate

Soil conditions likely to produce manganese deficiency

Pear trees growing in soil with a high pH may suffer from manganese deficiency.

Diagnosis by soil analysis

Manganese content in soil (mg/kg)

	Exchangeable Mn*	pH
Normal	3.8	5.85
Deficient	0.4	6.60

* Extracted with 1M ammonium acetate (neutral)

Diagnosis by plant analysis

Manganese content in leaf (mg/kg)

	Mn
Normal	25
Deficient	9

How to correct the deficiency

If the soil pH is higher than 6.5, no lime should be applied. To correct the deficiency, pear growers are recommended to apply manganese (manganese carbonate) at a rate of 100-200 kg/ha (basal application) once a year in autumn. Alternatively, a foliar application of 0.2% manganese sulfate solution, at a rate of 2 - 3000 L/ha, should be applied twice a year.

Photos and Information by Susumu Eguchi, Ferro Enamels (Japan) Ltd.

PEACH (*Prunus persica*)

Plate 81. Leaves of peach tree with manganese deficiency

Photo by Mr. Wei-Tin Huang, Taiwan Agricultural Research Institute

Taiwan: Subtropical climate

Plate 82

Plate 83

Plate 84

Plate 85

Plate 82. Manganese deficiency symptoms observed at the end of May in a peach orchard (var. Batch Hakuhau) established in a former paddy field
Plate 83. Young leaves of peach at top of canopy showing symptoms of manganese deficiency
Plate 84. Close-up of peach leaf damaged by manganese deficiency
Plate 85. Peach tree orchard with trees affected by manganese deficiency

Japan: Temperate climate

Photos by Dr. Manabu Wanaka, Japan

Description of symptoms

Leaves of peach trees suffering from manganese deficiency show interveinal chlorosis (i.e. the interveinal area is pale green or pale yellow in color). The veins remain green. The symptoms resemble those of magnesium deficiency, but symptoms of manganese deficiency occur in young leaves at the tip. Magnesium deficiency, on the other hand, occurs in the basal leaves of new growth. In Japan, symptoms appear in the middle of May, and yellowing advances to show clear interveinal chlorosis after June. Mildly deficient leaves often recover. If the deficiency is severe, the fruit are small and poor in color. Where the soil pH is higher than 6.5, flower buds often die or drop.

Soil conditions likely to result in manganese deficiency of peach

This condition is common in alkaline calcareous soils or sandy soil with good aeration, where ferrous manganese has been oxidized into manganese oxide. It is also found in soils with a high content of organic matter. High levels of phosphate, calcium, iron and zinc in the soil may hinder the uptake of manganese by the crop, and result in a state of manganese deficiency.

This condition is often found where the soil pH is raised to above 6.5 by heavy applications of lime. In Japan, manganese deficiency is common in drained paddy fields used for upland crop cultivation, where groundwater is close to the soil surface and the plow layer is shallow. In some cases, it occurs in sandy soils which have been given too much lime, and in Andosols.

Diagnosis by soil analysis

Manganese deficiency generally occurs because the manganese in the soil has become insoluble under alkaline conditions (pH of more than 6.5).

Diagnosis by plant analysis

The normal manganese content in the leaf ranges from 25 to 200 mg/kg. A manganese content in the leaf of less than 30 mg/kg is likely to result in slight damage (interveinal chlorosis). Less than 10 mg/kg is likely to result in severe deficiency symptoms.

How to correct the deficiency

Simply applying manganese fertilizer may not have any immediate effect, if the soil has a high pH. The application of liming materials or poultry manure should be discontinued. In Japan, in severely damaged orchards, growers are recommended to apply sulfur powder mixed with rice bran or sand, at a rate of around 300 kg/ha twice a year. The soil pH should be gradually lowered to 5.5 - 6.0.

A foliar application of 0.2 - 0.3% manganese sulfate solution is recommended. In Taiwan, it is applied once a week. In Japan, with a cooler climate, it is applied 2-3 times every 2 weeks, from the middle of May to the end of June. The effect does not last, so that the treatment needs to be repeated for damaged trees every year.

Information from Dr. Sakae Furuya, Nougyo-Giyutsu-Taikei, Japan, and Dr. Zueng-Sang Chen, National Taiwan University

TEA (*Thea sinensis* L. Sims)

Plate 86. The leaves of tea with manganese deficiency (left) show chlorosis or light green between the veins. Small mottles, yellow or dark brown in color, are found on the edges of the leaves. The veins remain green. On the right is a normal leaf.

Plate 87. Close-up of small, yellow or brown mottles on the edge of leaves, a symptom of manganese deficiency in tea.

Taiwan: Subtropical climate

Photos by Dr. Mu-Lein Lin, Taiwan ROC

Description of symptoms

Manganese deficiency manifests itself first as a lightening of the green color between the veins of the leaves. Small mottles may appear on the edges of the tea leaves.

How to correct manganese deficiency

The appropriate remedy is a foliar spray of 0.3% manganese sulfate ($MnSO_4$) solution. The pH of the soil should be adjusted to 5.5-6.5.

MULBERRY (*Morus bombycis* Koidz.)

Plate 88

Plate 89

Plate 90

Plate 91

Plate 88. Mulberry field (var. Roguwa) where manganese and iron deficiencies occur

Plate 89. Soil profile. Around 40 cm below the surface, there is a layer of light gray sandy soil (more than 1m thick) which contains many seashells.

Plate 90. Manganese-deficient mulberry trees in the field

Plate 91. Middle leaf of mulberry tree grown by hydroponic culture for more than four years in manganese-free nutrient solution

Japan: Temperate climate

Description of symptoms

First, chlorosis appears on the upper leaves. However, most of the leaves recover and turn green again. As the symptoms progress, the green color of the main veins and marginal fine veins looks clearer. Some trees have a combined deficiency of both manganese and iron. This makes it difficult to diagnose manganese deficiency on the basis of visible symptoms.

Soil conditions likely to produce manganese deficiency

This condition is often seen in areas where the surface soil is neutral or slightly alkaline, and the plow layer has a low manganese content. Alkaline soil may sometimes have slightly alkaline groundwater, as in Kihi, Japan.

Diagnosis by soil analysis

Soil deficient in manganese has only a few mg/kg Mn, by 1M ammonium acetate (neutral) extraction.

Diagnosis by plant analysis

Leaves of a mulberry tree deficient in manganese contain less than 30 mg Mn/kg.

Interaction with other elements

In general, manganese-deficient leaves have a high iron content, while iron-deficient leaves of course have a low iron content. Otherwise, it may be difficult to tell from leaf analysis whether the tree is suffering from iron deficiency, manganese deficiency or both.

Photos and information from Dr. Syozo Higashino, National Institute for Agro-Environmental Sciences, Japan