Nutritional disorders in chrysanthemums

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The Instituut voor Bodemvruchtbaarheid (Institute for Soil Fertility) is a governmental institution. Research work includes various aspects of soil physics, soil chemistry and soil organic matter, and of plant nutrition and fertilizer application. The Proefstation voor Tuinbouw onder Glas (Glasshouse Crops Research and Experiment Station) is also a governmental institute. The aim of the research work is to increase production and to improve quality of vegetables, fruits (grapes and strawberries) and some flower crops (e.g. chrysanthemums) grown in glasshouses. Consequently, all aspects of cultivation under glass are studied.

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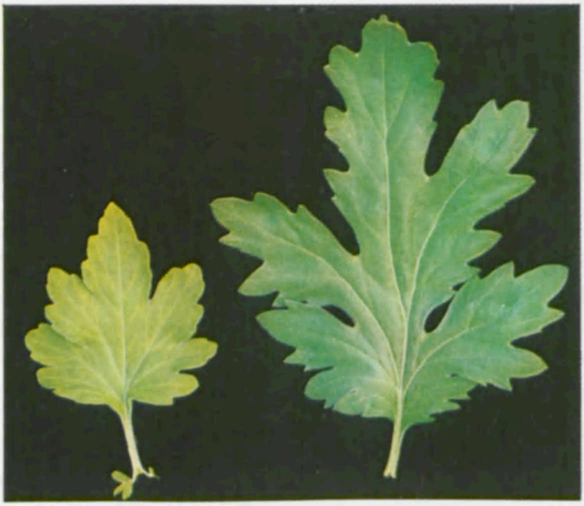
Introduction

In the Netherlands chrysanthemums *(Chrysanthemum* hybr., also designated *C. morifolium* Ramat or *C. indicum* L.) are mainly cultivated as a year-round crop under glass, either as cut or pot chrysanthemums. Cultivation in the open (in autumn) is of less importance. Chrysanthemums are propagated vegetatively by cuttings. For a more detailed description of cultivars, methods of cultivation etc. the reader is referred to the following books: Gosling (1964), Langhans (1964), Buijs & van Veen (1968), Searle & Machin (1968), Vogelmann (1969), Gloeckner (1974) and Bürki (1975). Literature data on chrysanthemum nutrition were summarized recently by Roorda van Eysinga (1978).

This book is a guide to diagnosing nutritional disorders in chrysanthemums. Deficiencies and toxicities are included, fifteen in all. Molybdenum deficiency is excluded as specific symptoms are unknown so far and our attempt to induce them have failed. Only four more characteristic toxicities are described here, from the twelve distinguished in literature.
As many of the nutritional disorders do not occur in practice, they were induced by growing chrysanthemums in peat moss substrates, in nutrient solution or in rock wool. Symptoms may differ considerably between cultivars. The references at the end of each chapter indicate publications dealing with symptoms.

Conditions pertaining to mineral disorders and methods of control are briefly described. Leaf nutrient concentrations typical for the various deficiencies and toxicities are reported and compared with literature data. In our trials young, just fully grown leaves were sampled for foliar analysis. Supplementary data were obtained from published reports.
The photographs were taken by messrs. J. van der Loos (Glasshouse Crops Research and Experiment Station, Naaldwijk) and J. J. Klinkhamer (Institute for Soil Fertility, Haren-Gr.).

To the left nitrogen-deficient plant; to the right healthy plant (cv. Hurricane)



To the left leaf (cv. Pink Marble) showing nitrogen deficiency; to the right healthy leaf (cv. Spider)

Nitrogen deficiency

Symptoms

Growth is restricted. Leaves are smaller than normal and pale green. Terminal leaves may be somewhat darker (cv. Spider) or paler than older ones, depending on the cultivar. Pink or reddish-brown spots sometimes affecting the entire (older) leaf may appear in some cultivars, older leaves dying subsequently. Flower colour is deeper or paler than normal, depending on the cultivar. In severe cases flowering is delayed, sprays contain fewer and smaller flowers. Nitrogen-deficient plants have a dense root system. Symptoms of nitrogen and sulphur deficiency are rather similar.

Leaf concentration

In healthy plants total N ranges from 1.8 to 3.6 mmol per g leaf dry matter, with 3.04 mmol/g as a mean value calculated from a large number of data. Leaves from nitrogen-deficient plants contain 0.7 mmol/g or less. Nitrate-N normally ranges from 0.14 to 1.14 mmol/g, levels below 0.07 mmol/g indicating deficiency.

Incidence

Nitrogen deficiency is promoted either by applying undecomposed organic materials or by excess water, especially if plants are grown in small pots.

Control

Where an irrigation system is available, the liquid feed should contain 200-500 mg N per litre. Spraying with urea (2 g per litre) is less effective.

References

2, 8, 17, 25, 26, 36, 37, 43, 44, 46-52, 57, 60, 62, 69, 73-75, 79-81.

Plants showing phosphorus deficiency. To the left cv. Spider; to the right cv. Marble. Plants grown in peat substrate

Plants (cv. Spider) grown on peat and showing phosphorus deficiency

Phosphorus deficiency

Symptoms

Plants are somewhat stunted but show no distinct symptoms at first. Leaves have a dark or dull green colour and may turn pink or yellow in some cultivars, the discoloration starting here and there along the leaf edges. Oldest leaves die prematurely and turn dark brown but remain attached to the stem.
Flowering may be delayed and flowers are sometimes reported to remain small. Only a few authors have mentioned a pale flower colour.

Leaf concentration

P concentrations in healthy crops are in the range of 0.10 to 0.30 mmol per g leaf dry matter, 0.15 mmol/g being the mean of several reported values. Phosphorus deficiency is to be expected in crops with less than 0.06 mmol/g.

Incidence

Phosphate deficiency occurs in newly built glasshouses when phosphate dressing has been neglected, and in pot chrysanthemums when phosphate has not been applied.

Control

In severe cases it is recommended to discard the current crop and start a new one after a large application of phosphate fertilizer.

References

2, 8, 17, 24-26, 36, 37, 43, 44, 46, 48, 49, 51, 52, 57, 62, 69, 73, 75, 78, 79.

Leaf of potassium-deficient plant (cv. Spider)

Plant (cv. Brown Marble) grown in water culture and showing potassium deficiency. To the right a small part of a healthy plant

Potassium deficiency

Symptoms

Potassium deficiency symptoms are not obvious. Growth is hardly restricted but shoots are thin and feeble. Chlorosis, often starting as small spots (1 to 2 mm in diameter) coalescing at a later stage, appears in leaf margins and subsequently extends to interveinal tissues. In general, specially older leaves are affected and die, the pattern of marginal scorch spreading to younger leaves. According to some authors between leaf differences in symptoms are less pronounced than reported here.
Flower colour is normal or pale according to the cultivar. There is a delay in flowering.

Leaf concentration

Leaf K in healthy crops is reported to range from 0.67 to 1.56 mmol per g dry matter, with a mean value of 1.37 mmol/g. Potassium deficiency is associated with leaf K concentrations of less than 0.50 mmol/g.

Incidence

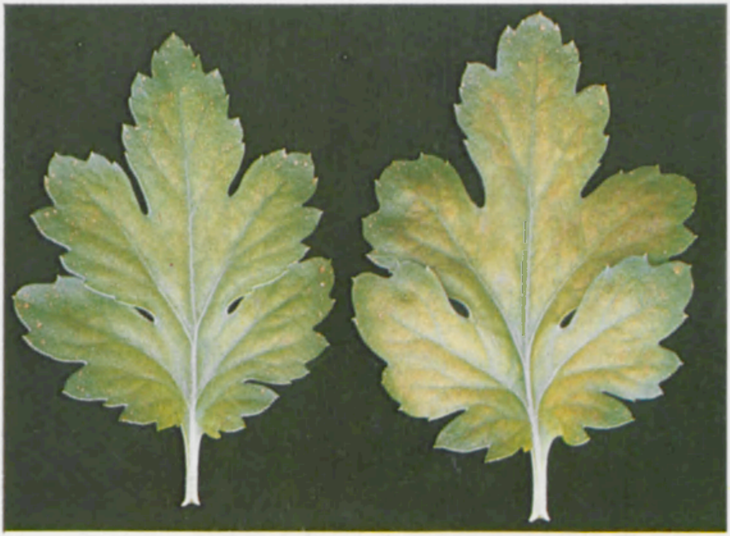
Potassium deficiency is to be expected in all cases where application of potash fertilizers has been neglected.

Control

Apply potash fertilizer in the liquid feed (500 mg K per litre). Spraying, with a solution containing 10 to 20 g potassium sulphate per litre, is not very effective.

References

2, 3, 8, 17, 25, 26, 30, 31, 36, 37, 43, 44, 46-49, 51, 52, 57, 60, 62, 69, 73, 75, 79.



Leaves of plants (cv. Pink Marble) grown in water culture and showing magnesium deficiency

Plant (cv. Bonnie Jean) grown in water culture and showing magnesium deficiency

Magnesium deficiency

Symptoms

Growth is only stunted in severely affected plants. Interveinal chlorosis is typical for older leaves in chronic deficiency and for younger leaves in acute deficiency. Veins remain green and so do the margins at first. In some cultivars purple discolorations may be observed in the leaves.

Flowering and root development are suppressed in severe cases only.

Leaf concentration

In healthy crops leaf Mg lies between 0.14 and 0.41 mmol per g dry matter, with 0.21 mmol/g as the mean value calculated from a large number of reported data. Malnutrition symptoms may occur in crops with less than 0.06 mmol/g.

Incidence

Unlike other crops such as tomatoes, chrysanthemums are rather tolerant of magnesium deficiency (Winsor, 1972). The disorder is promoted by excess potash fertilizer.

Control

Too high a potassium status of the soil should be avoided. It is further recommended to use nitrate rather than ammonium as a nitrogenous fertilizer. Spraying with a solution containing 20 g magnesium sulphate per litre, may also be effective.

References

1, 2, 8, 11, 12, 20, 25, 26, 31, 36, 44, 46, 48, 49, 51, 52, 54, 57, 69, 79.

Under side of flowers showing calcium deficiency; plants (cv. Spider) grown in water culture

To the left top of plant (cv. Spider) grown in water culture and showing calcium deficiency; to the right more advanced stage of the same plant

Calcium deficiency

Symptoms

Growth is somewhat stunted. Leaves are dark green, but brown spots appear in older leaves. In severe deficiency growing points die. Youngest leaves remain very small and necrotic spots rapidly develop in the leaf tissue, especially in the margins. Severely affected young leaves curl downward and desiccate, entire leaves coiling upwards.
Flowering shoots may collapse and die. Flowers remain small, petals are badly developed and may turn brown. Flowers are reported to be easily injured by heat. Calcium-deficient plants have poorly developed roots and are susceptible to some fungus diseases.

Leaf concentration

In healthy crops leaf Ca ranges from 0.25 to 0.68 mmol per g leaf dry matter, with a mean value of 0.35 mmol/g. According to our analyses leaves of calcium-deficient plants contained 0.25 mmol/g, which is somewhat higher than the level of 0.13 mmol/g reported in literature.

Incidence

Calcium deficiency may occur on acid soils given excess potassium and/or magnesium. In practice, such conditions do not normally occur, with a possible exception for unlimed peat moss substrates. In nutrient solution the disorder is induced by omitting calcium.

Control

Lime the soil and substitute healthy cuttings for the calcium-deficient crop. Spraying the affected (current) crop with a solution of 2 g calcium nitrate per litre may be considered.

References

2, 8, 17, 25, 26, 36, 44, 46, 48, 49, 51, 57, 69, 79, 82.

To the left plant showing sulphur deficiency; to the right healthy plant. Both plants (cv. Shoesmith) grown in water culture

Sulphur deficiency

Symptoms

Growth is stunted and leaf size is reduced. Leaves are yellowish-green in colour and sometimes veins become even paler than surrounding leaf tissues (Laurie & Wagner, 1940). Necrotic spots may appear in older leaves, in acute deficiency resulting in premature death of the leaf affected. In severe cases flowering is suppressed. Sulphur-deficient plants have a dense root system. The symptoms resemble those of nitrogen deficiency.

Leaf concentration

In healthy plants total-S is reported to range from 0.09 to 0.22 mmol per g leaf dry matter, with a critical level of 0.08 mmol/g (Lunt et al., 1963, 1964). Under normal conditions SO_4-S varies from 0.04 to 0.11 mmol/g. In our experiments plants with distinct deficiency symptoms contained 0.01 mmol/g.

Incidence

Sulphur deficiency is not to be expected in protected cultivation. In nutrient solution it is induced by omitting sulphate.

Control

Apply potassium sulphate, preferably in liquid form.

References

8, 36, 46, 48, 49, 54.

Boron-deficient plant (cv. Spider) grown in water culture

Boron-deficient plant (cv. Delaware) grown in water culture (longitudinal section of stem)

Boron deficiency

Symptoms

Growth of the main shoot is restricted and internodes remain short. Growth of lateral shoots may be inhibited in some cultivars and promoted in others. Leaves are thick, stiff or brittle, the colour being somewhat deeper, and in more severe deficiency paler than normal. Also reddish or purple discolorations, depending on the cultivar, may appear. Corky veins and top leaves with abnormal shapes are reported in literature.

Bud formation is impaired. Flowers are small and distorted, turning brown or black in colour. Petals fail to unroll properly (quilling). Root development is strongly restricted.

Leaf concentration

A mean value of 5.7 μmol B per g leaf dry matter was calculated from data on the chemical composition of healthy crops. Boron deficiency is likely to occur in crops containing less than 2.3 μmol/g.

Incidence

Boron deficiency is favoured by a high pH of the substrate in the absence of adequate boron.

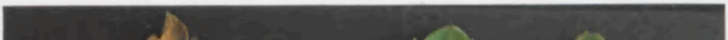
Control

Apply 10 g of borax per m^3 potting substrate. Boron may also be added to the liquid feed, e.g. 0.5 mg B per litre continuously or 2 mg per litre periodically. Spraying with a solution containing 0.8 g borax per litre is recommended by Waters & Conover (1969).

References

2, 4, 5, 8-10, 13-16, 21, 25, 26, 32, 36, 44, 49, 51, 53, 57, 63, 64, 69-71, 79, 82.

To the left copper-deficient plant; to the right healthy plant. Both plants (cv. Spider) grown on peat substrate



Leaves of copper-deficient plant (cv. Yellow Indianapolis) grown on peat substrate

Copper deficiency

Symptoms

Growth is not severely affected generally. Lateral shoots may become abnormally long. Middle leaves show transparent sunken papery spots that coalesce, in severe cases resulting in desiccation of the entire leaf blade. Veins are sometimes reported to become paler than surrounding leaf tissues. This phenomenon is known as 'inverse netting' (Woltz, 1959 and Waters & Conover, 1969).

The most characteristic manifestation of copper deficiency is suppression of flowering. Flowering is strongly delayed and flower buds completely fail to develop in acute cases. Roots show a brown discoloration (Graves, 1971).

Leaf concentration

A mean value of 0.27 μmol Cu per g leaf dry matter of healthy crops may be derived from literature data. Copper deficiency is to be expected in crops with less than 0.16 μmol/g.

Incidence

Copper deficiency is to be expected in pot chrysanthemums grown in peat moss or in water culture without copper.

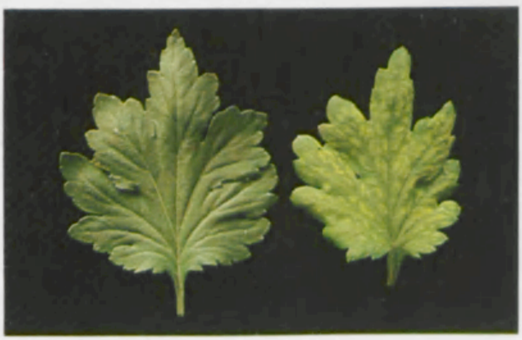
Control

In severe deficiency it is probably best to start a new crop and discard the old one. Spraying with a solution containing 400 mg copper sulphate per litre is sometimes recommended (Adams, 1965). Graves et al. (1978) obtained good results in pot chrysanthemums, grown in peat/sand substrates, by applying 0.5 mg Cu per pot (15 cm ø) dissolved in 100 ml water.

References

2, 4-6, 16, 33-35, 49, 59, 63, 64, 66, 69-72, 79, 81, 82.

To the left manganese-deficient plant; to the right healthy plant. Both plants (cv. Elzas) grown in rock wool



To the left leaf of healthy plant; to the right leaf of manganese-deficient plant. Both plants (cv. Spider) grown in water culture

Manganese deficiency

Symptoms

Plant growth is little affected. The whole plant shows a loss of colour and leaves turn uniformly pale green. Sometimes leaf colour is described as dull or grey. With a more severe deficiency, depending on season (Messing & Owen, 1954) and cultivar besides lack of manganese, chlorosis is more patchy and designated as 'interveinal'. Chlorosis is most pronounced in middle and older leaves.

Bud development is delayed and flowers are somewhat reduced in size.

Leaf concentration

In healthy crops leaf Mn may range from 0.27 to 4.55 μmol per g dry matter.

A mean value of 4.09 μmol/g was calculated from published data. Manganese deficiency is associated with leaf Mn levels lower than 0.27 to 0.36 μmol/g.

Incidence

Deficiency occurs on calcareous loamy and overlimed sandy soils.

Control

Spray with a solution containing 1 g manganese sulphate per litre. Soil application of manganese chelate is sometimes recommended.

References

2, 8, 20, 22, 26, 31, 39, 46, 49, 51, 52, 56, 57, 63, 69, 79, 82.

Top of iron-deficient plant (cv. Hurricane) grown in water culture

From left to right increasing severity of iron deficiency in leaves of plants (cv. Spider) grown in water culture

Iron-deficient plant (cv. Blue Marble) grown in water culture

Iron deficiency

Symptoms

Growth is more or less stunted. Chlorosis starts at the plant top and proceeds to the base. Youngest leaves turn uniformly yellow and in severe deficiency almost white, the larger veins remaining green at first. In older leaves the chlorotic pattern is more interveinal. Small necrotic spots, 2 mm in diameter, may appear, coalescing into large desiccating areas affecting most of the leaf blade. Flower bud formation is feeble and delayed. Flowers remain small and have a pale colour. The root system is poorly developed. Cuttings from iron-deficient plants are prone to fungal rot (van der Hoeven, 1973).

Leaf concentration

A mean value of 4.23 μmol Fe per g leaf dry matter of healthy crops may be calculated from published reports. In our experiments chlorosis was found to occur in crops containing less than 2.50 μmol/g. However, much lower critical values (0.72 μmol/g) are reported in literature (Nelson, 1969). Apparently, total-Fe in leaf dry matter is not the proper criterion for iron deficiency.

Incidence

Iron deficiency may be expected on calcareous (loam) soils. Water logging and excessive applications of certain organic materials, like dried blood (Adams, 1975), are conducive to this disorder.

Control

Apply iron chelate to the soil. At higher pH values EDDHA is more effective than EDTA.

References

2, 8, 14, 16, 26, 31, 36, 38, 46, 49, 52, 53, 57, 63, 68, 69, 72, 79, 82.

Zinc-deficient plant (cv. Spider) grown in water culture

Zinc deficiency

Symptoms

Mainly in mature plants growth is stunted, giving the plant a rosette appearance. Middle and older leaves curl downwards and exhibit chlorotic spots coalescing into an irregular chlorosis pattern. In severe deficiency entire leaves and stem sections coil up and necrotic spots appear in the chlorotic areas.
Flowers remain small.

Leaf concentration

A mean value of 1.41 μmol Zn per g leaf dry matter of healthy crops was calculated from literature data. Concentrations of less than 0.11 μmol/g indicate zinc deficiency.

Incidence

Zinc deficiency is unlikely to occur in glasshouses. It may be induced in nutrient solution when zinc is omitted.

Control

Spray with a solution containing 0.3 g/l zinc sulphate or 0.6 g/l zinc chelate (Waters & Conover, 1969).

References

26, 49, 65, 69, 79.

Nitrogen (nitrate) excess in plant (cv. Spider) grown in water culture

Nitrogen (nitrate) excess

Symptoms
Growth is restricted. Leaves are thick or brittle and deep green. In acute toxicity especially older leaves wilt and scorch from the margins inward. Some authors mention chlorosis in top leaves or abnormalities like decapitation (Jannone & Binaghi, 1962), stem splitting and compounding, i.e. multiple development of leaf axil buds (Butters, 1970). The affected crop is more susceptible to pests and diseases.
Flowering is delayed, bloom colour is abnormal and keeping quality inferior. Bürki (1975) mentions scorching of the root system.

Leaf concentration
According to Wadsworth & Butters (1972) plants suffering from nitrogen toxicity had 4.50 mmol total-N per g leaf dry matter. Bunt's (1973) data presenting the relationship between leaf total-N and delay in flowering showed 4.29 to 4.64 mmol/g to be in the high range.

Incidence
Excess nitrogen is induced by heavy nitrogenous fertilizer dressings, and also by large applications of organic materials such as dried blood.

Control
Excessive watering or flooding.

References
2, 7, 16-18, 37, 40-42, 47, 52, 75, 80.

Boron toxicity in plant (cv. Neptune) grown in water culture

Leaves of plants (cv. Blue Marble) grown in soil affected by boron toxicity

Boron excess

Symptoms
Growth is slightly restricted. Tips and edges of leaves exhibit necrotic spots coalescing into a typical marginal scorch. Symptoms proceed from the plant's base upwards, the oldest leaves being affected first.
At more advanced stages necrotic spots with a pale brown centre appear also in the inner parts of the leaf blade, and coalesce into large dry patches finally including the whole leaf. The desiccated leaf tissue, in which dark and pale brown parts alternate, feels papery to the touch. Some authors report interveinal chlorosis.
In severe toxicity flowers remain small and sepals exhibit marginal scorch.

Leaf concentration
Leaf boron concentrations exceeding 9.1 μmol B per g leaf dry matter are indicative of boron toxicity.

Incidence
Injudicious borax dressings or using water with too high a boron concentration (more than 1 mg B per litre, Walton, 1968) may induce boron toxicity. Cultivars differ in tolerance. Plant injury is mitigated by a high soil pH.

Control
Leach excessive amounts of boron from the soil, preferably with calcareous water. However, this may present difficulties during cropping. Other measures to increase soil pH are also recommended.

References
2, 13-15, 19, 23, 28, 29, 49, 55, 61, 69, 72, 77, 79.


Plant (cv. Tuneful) showing manganese toxicity


Leaves of plants grown in water culture and showing manganese toxicity. Upper, cv. Spider; lower, cv. Pink Daisy

Manganese excess

Symptoms

Growth is restricted. Terminal leaves show chlorosis resembling iron deficiency. At first main veins and adjoining leaf tissues remain green or yellowish-green. Smaller veins may turn brown. Small necrotic spots, 1 to 2 mm in diameter, appear in older leaves and spread from the margins inwards, finally including the entire (desiccating) leaf blade. At more advanced stages younger leaves also display this spotting.
Flower bud formation is reduced and sometimes fails completely. Flowers remain small and their centres may wither.

Leaf concentration

Leaf concentrations of 15.5 μmol Mn per g leaf dry matter are associated with manganese toxicity in some cultivars, other cultivars tolerating much higher levels though.

Incidence

Steaming the soil releases large amounts of plant-available manganese which may result in manganese toxicity, especially at a low soil pH. Cultivars differ in susceptibility, for instance the tolerant cv. Indianapolis versus the very susceptible Marble types.

Control

In severe cases starting a new crop should be considered. Raise pH, for instance by using calcareous irrigation water. Furthermore, Adams (1975) suggested to add 0.6 g monoammonium phosphate per litre irrigation water if the plant substrate contains little phosphate.

References

2, 53, 56, 57, 80, 81.

Zinc toxicity in plant (cv. Spider) grown in water culture

To the left, plant showing zinc toxicity; to the right, healthy plant. Both plants (cv. Bonnie Jean) grown in water culture

Zinc excess

Symptoms

Growth is restricted, especially when chlorosis symptoms are more severe. Entire leaves are affected by chlorosis, but edges and leaf tissues near main veins often retain more colour (chlorophyll). In some cultivars loss of colour is worst in terminal leaves. Irregular necrotic spots, surrounded by chlorotic tissue, may appear in edges of older leaves that die subsequently. Plants easily wilt.
There is a slimy decay of the roots.

Leaf concentration

Growth may be impaired in plants containing over 13.8 μmol Zn per g leaf dry matter. Leaves with distinct zinc toxicity symptoms were found to contain 22.3 μmol/g.

Incidence

Zinc toxicity may occur in glasshouses with a galvanized frame or irrigation system when zinc containing particles or (condensation) water mix with the soil. Similarly, nutrient solutions in contact with galvanized materials may induce the disorder.

Control

During cropping apply tentatively iron and manganese chelate to the soil, or combine iron chelate with a foliar spray of manganese sulphate. After cropping apply lime and farmyard manure.

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54.

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