MOLYBDENUM DEFICIENCY IN YOUNG LETTUCE AND TOMATO PLANTS

J. van den Ende and G. A. Boertje
Glasshouse Crops Research and Experiment Station
Naaldwijk, The Netherlands

Introduction

The Dutch vegetable growers obtain their potting soil from suppliers specialising in composing potting soil. In the western part of the Netherlands the potting soil is often made of a mixture of low-moor and high-moor peat to which sand and fertilizers are added. It is known by experience that dressings of trace elements get more important as the percentage of high-moor peat in the potting soil increases. In the propagation of lettuce, tomato and some other vegetables especially the trace element molybdenum is of importance.

Symptoms of molybdenum deficiency

Molybdenum deficiency in lettuce can be known by the colour and turgidity of the leaves. Starting at the older leaves the leaf colour turns pale green and in later stages yellow. However, the colytedons keep almost their normal colour. The ordinary leaves flag. Beginning at the leaf tips the leaves may shrivel and die.

In tomato molybdenum deficiency brings about interveinal chlorosis. The leaflets, including the young ones, show a pale green to yellow mottling. The margins of the chlorotic leaflets curl upwards. The chlorosis may pass into necrosis. In cases of severe deficiency entire leaves shrivel and die.

Causes of molybdenum deficiency

Several factors can affect the occurrence of molybdenum deficiency during propagation. We mention:

1. The composition of the peat;
2. The pH of the potting soil;
3. The source of the available nitrogen.

Each of these factors will be discussed in detail.

Other factors may affect the occurrence of molybdenum deficiency as well. Reeker (1959) found that the symptoms of molybdenum deficiency appear more often in winter than in summer. Our experiences in practice tend to confirm this. Besides, we have got the impression that the appearance of molybdenum deficiency is promoted by a high moisture content of the potting soil.

The peat

We already mentioned that in the western part of The Netherlands the potting soil is often made of a mixture of low-moor and high-moor peat. All high-moor peats used are deficient in trace elements. The low-moor peat used, won mainly in a lake district situated in the centre of The Netherlands, has a higher pH, contains more salts and is richer in trace elements than high-moor peat. The symptoms of molybdenum deficiency almost never appear in lettuce and tomato plants which are raised in low-moor peat only. If high-moor peat only is used and no measures are taken to prevent molybdenum deficiency, the plants nearly always become chlorotic.

Several years ago much potting soil was composed of 75% low-moor peat and 25% white peat (a young high-moor peat). In order to improve the physical properties of the potting soil nowadays more white peat is added. Consequently more attention must now be paid to molybdenum fertilising. Potting soils made almost completely of high-moor peat are also for sale, for instance potting soils composed of white peat and frozen- or unfrozen black peat (an old high-moor peat). These potting soils must always be dressed with molybdenum.

The pH

The occurrence of molybdenum deficiency during propagation is closely connected with the pH of the potting soil. This was clearly shown in two experiments with lettuce and tomato plants. High-moor peat was used as substratum in these experiments. By means of liming three pH levels were induced in the peat. There were treatments with and without addition of molybdenum at each pH level. Results of the experiments are presented in tables 1 and 2.

In both experiments severe molybdenum deficiency was observed. The severity of the deficiency symptoms decreased with increasing pH. In the tomato experiment no deficiency symptoms appeared at the highest pH level. A dressing of ammonium molybdate prevented the occurrence of molybdenum deficiency completely in both experiments.

The growth of both lettuce and tomato plants was improved considerably by molybdenum application at the lowest pH level. At the higher pH levels, however, this affect showed up in the lettuce experiment only. It is noteworthy that for the propagation of vegetables a pH of 5. 5-6. 0 is aimed at in Dutch potting soils.

The available nitrogen

Molybdenum is essential in the process of nitrate reduction in plants. In molybdenum-deficient plants nitrate nitrogen is utilized inadequately and may accumulate to toxic levels. Many research workers found that more molybdenum is needed for growth with nitrate nitrogen than where ammonium nitrogen is used (CBS, 1957). Typical symptoms of molybdenum deficiency often occur only in plants which have been dressed with nitrate nitrogen. This was observed also in one of our experiments with tomato plants. No deficiency symptoms appeared in tomato plants supplied with ammonium nitrogen. However, according to literature molybdenum has a multiple role in plant metabolism as shown for instance by the fact that plants grown with ammonium nitrogen also require some molybdenum for normal growth (CBS, 1957).

In an experiment with lettuce plants grown in white peat with and without addition of molybdenum, nitrate- and total-nitrogen contents of the leaves were determined. Results of the analyses are given in table 3. The leaves of the plants grown without addition of molybdenum contained much more nitrate than those of the plants grown with sufficient molybdenum. The total-nitrogen content of the leaves was almost the same in both treatments.

In another experiment with lettuce plants nitrate- and nitrite contents of leaf sap were determined. The plants were grown in white peat in which two pH levels were induced by means of liming. There were treatments with and without addition of molybdenum at both pH levels. Results of the analyses are listed in table 4.

In the treatments in which no molybdenum was applied, the leaf sap had a high nitrate content. In one of these treatments, that with a low pH level, a relatively high nitrite content was found as well. In experiments with molybdenum-deficient tomatoes Spencer and Wood (1954) found that molybdenum application temporarily increased the concentration of nitrite. This finding suggests that the high nitrite content found in the above-mentioned treatment of our experiment results from reduction of nitrate and that some traces of molybdenum must have been available, at least shortly before the analyses were performed.

Molybdenum content of plants

In one of our experiments with lettuce plants, the molybdenum content of the leaves was determined. The plants, grown in white peat* with and without addition of molybdenum, were healthy and molybdenum-deficient, respectively. The molybdenum-deficient leaves contained 0. 22 ppm Mo in the dry matter and the healthy ones 0. 50 ppm.

Johnson, Pearson and Stout (1952) found in tops of molybdenum-deficient tomatoes 0. 13 ppm Mo in the dry matter and in healthy tops 0. 61 ppm. Stanton (1966) reported for healthy tomato leaves contents of 0. 3-0. 4 ppm.

For neither lettuce, tomato nor any other crop can one definite critical molybdenum level be expected. We already mentioned that the amount of molybdenum needed for growth depends on the source of the available nitrogen. The need of molybdenum may depend on several other circumstances as well. Roorda van Eysinga and Smilde (1971) state that molybdenum levels sufficient for good growth of lettuce plants vary, according to the literature, from 0. 03-3. 2 ppm.

According to our experiences lettuce is more prone to molybdenum deficiency than tomato. Johnson, Pearson and Stout (1952) had the same experience.

Control of molybdenum deficiency

The data given before show that in the propagation of lettuce and tomato plants in potting soils made of high-moor peat the occurrence of molybdenum deficiency can be prevented by molybdenum fertilizing. They also show that liming has a favourable effect as well, but usually does not prevent the deficiency completely, at least if no more lime is applied than is needed to reach a pH of 5, 5-6, 0 which is aimed at in Dutch potting soils. Besides, it has been shown that when no molybdenum is applied the deficiency can sometimes be prevented by using nitrogen fertilizers

---

* pH of white peat : 4. 0
molybdenum dressing : 6 grammes $(NH_4)_6 Mo_7 O_{24}. 4H_2O/m^3$ peat
nitrogen dressing: 160 grammes N/m^3 peat (95 NH_4-N + 65 NO_3-N).

which contain ammonium nitrogen only.

There are still some other methods of control. Experiments with lettuce and tomato plants have shown that an acute molybdenum deficiency can be controlled by spraying the plants with a 0.05-0.1% solution of ammonium molybdate. In other experiments it was found that the occurrence of molybdenum deficiency can be prevented by soaking the seeds in a 5% solution of ammonium molybdate.

In the last mentioned experiments the seeds were soaked for eight hours and then sown directly. They were not washed out before sowing as was done by Wilson and Notley (1959). The young seedlings were grown in white peat without added molybdenum. The controls were plants from untreated seeds grown in white peat with and without a molybdenum dressing. Results of a tomato experiment are given in table 5. Similar results were obtained in an experiment with lettuce. The experiments show that the seed-soaking treatment is able to prevent the occurrence of molybdenum deficiency. However, it is easier to add molybdenum to the potting soil than to treat the seeds with molybdenum solution, for sowing wet seeds is not easily practicable. Drying the seeds before sowing is too cumbersome and may be detrimental to seed quality. At present many seeds are pelletted and then they cannot be soaked. However, addition of molybdenum to the pelletting material may offer possibilities.

The most important menthod of control is molybdenum fertilizing. In experiments with tomato plants Spithost (1969) found no important differences in growth with dressings of 2 and 10 grammes Mo per cubic metre white peat. In experiments with lettuce plants we ourselves did not observe growth differences with dressings of 2 and 5 grammes. From these experiments we conclude that a dressing of 2-3 grammes Mo is sufficient.

Summary

Experiments have shown that raising lettuce and tomato plants in high--moor peat requires addition of molybdenum. In lettuce molybdenum--deficiency symptoms are light-coloured leaves and flagging of the older leaves. Molybdenum-deficient tomatoes show leaf mottling.

The occurrence of molybdenum deficiency during propagation is mainly caused by insufficient molybdenum in the potting soil. However, other factors can have an important influence as well. Especially a low pH of the potting soil promotes the occurrence of molybdenum deficiency. The deficiency symptoms appear more quickly when the potting soil contains a good deal of nitrate nitrogen.

Deficiency symptoms in young plants can be controlled by spraying with a 0. 05-0. 1% solution of ammonium molybdate. However, a dressing of 5 grammes ammonium molybdate per cubic metre potting soil can prevent the occurrence of molybdenum deficiency completely.

Zusammenfassung

Versuche ergaben dasz bei der Anzucht von Tomaten- und Kofpsalatjungpflanzen in Hochmoortorf eine Molybdändüngung notwendig ist. Kopfsalat mit Molybdänmangel zeigt blaszgrüne Blätter und Welken der älteren Blätter. Bei Tomaten mit Molybdänmangel sind die Blätter mar-

moriert.

Das Auftreten von Molybdänmangel während der Anzucht wird hauptsächlich verursacht durch zu wenig Molybdän in der Erde. Auch andere Faktoren können jedoch einen groszen Einflusz haben und sogar eine ausschlaggebende Rolle spielen. Niedrige pH-Werte und hohe Nitratstickstoffgehalte fördern das Auftreten.

Molybdänmangel kann bekämpft werden durch Spritzen mit 0. 05-0. 1% Lösung von Ammoniummolybdat. Verabreichung von 5 g Ammoniummolybdat pro m3 Erde gibt eine sichere Verhütung.

References

1. Commonwealth Bureau of Soils, 1957. Bibliography of molybdenum in plant nutrition.
2. Johnson, C. M., Pearson, G. A. and Stout, P. R., 1952. Molybdenum nutrition of crop plants. II. Plant and soil factors concerned with molybdenum deficiencies in crop plants. Plant and soil 4:178-196.
3. Reeker, R., 1959. Die Verhütung des Molybdänmangels bei Verwendung von Torf als Substrat. Gartenbauwiss. 24:528-545.
4. Roorda van Eysinga, J. P. N. L. and Smilde, K. W., 1971. Nutritional disorders in glasshouse lettuce. Centre Agr. Publ. Doc., Wageningen, 56 pp.
5. Spencer, D. and Wood, J. G., 1954. The role of molybdenum in nitrate reduction in higher plants. Aust. J. biol. Sci. 7:425-434.
6. Spithost, L. S., 1969. Spoorelementenbemesting in oligotroof veen voor het opkweken van tomatenplanten. Tuinbouwmeded. 32:499-506.
7. Stanton, D. J., 1966. Report on tomato trials. Cawthron Institute, Triennial Report, 1963-1966:25-27.
8. Wilson, G. L. and Notley, L. F., 1959. Seed soaking as a method of supplying the molybdenum requirements of lettuce and tomatoes. Aust. J. agr. Res. 10:621-627.

Table 1 - Effects of substratum pH and molybdenum application on young tomato plants.

$CaCO_3$ dressing kg/m3 substratum	substratum pH	ammonium molybdate dressing	molybdenum deficiency 0=none 10=very severe	plant weight g/pl.
2	4. 7	-	9	17. 8
2	4. 7	+	0	26. 8
6	5. 7	-	2	25. 6
6	5. 7	+	0	26. 6
20	6. 4	-	0	24. 8
20	6. 4	+	0	22. 3

Substratum : 50% white peat and 50% black peat
Nitrogen dressing: 200 grammes NO_3-N/m3 substratum

Table 2 - Effects of substratum pH and molybdenum application on young lettuce plants.

$CaCO_3$ dressing kg/m3 substratum	sub-stratum pH	ammonium molybdate dressing	molybdenum deficiency 0=none 10=very severe	leaf colour 1=very pale 10=very dark	plant weight g/pl.
1. 5	4. 4	-	10	1	1. 5
1. 5	4. 4	+	0	6	12. 9
6	5. 5	-	8	3	7. 5
6	5. 5	+	0	6	11. 9
20	6. 5	-	6	4	10. 3
20	6. 5	+	0	5	11. 4

Substratum : white peat
Nitrogen dressing: 160 grammes N/m3 substratum (95 NH_4-N + 65 NO_3-N)

Table 3 - Nitrate- and total-nitrogen contents of the leaves of young lettuce plants grown in white peat with and without addition of ammonium molybdate.

	- Mo	+ Mo
Total - N (% of dry matter)	5. 63	5. 77
NO_3 - N (% of dry matter)	1. 17	0. 39

pH of white peat : 4. 0
Nitrogen dressing: 160 grammes N/m3 peat (95 NH_4-N + 65 NO_3-N)

Table 4 - Nitrate and nitrite in young lettuce plants grown in white peat at two pH- and two molybdenum levels (peat dressed and not dressed with ammonium molybdate).

pH of white peat	molybdenum dressing	NO_3 in leaf sap me/l	NO_2 in leaf sap me/l
4. 2	-	48. 3	0. 034
4. 2	+	13. 8	0. 004
5. 4	-	42. 3	0. 005
5. 4	+	12. 3	0. 004

Nitrogen dressing: 160 grammes N/m3 peat (95 NH_4-N + 65 NO_3-N)

Table 5 - Effects of a dressing with ammonium molybdate and a seed-soaking treatment with an ammonium molybdate solution on young tomato plants.

	molybdenum deficiency 0= none 10=very severe	plant weight g/pl.
no treatment with Mo	9	17. 8
dressing of Mo	0	26. 8
seed treatment with Mo	1	27. 2

Substratum : 50% white peat and 50% black peat
pH of substratum : 4. 7
Nitrogen dressing: 200 grammes NO_3-N/m3 substratum