Statens plantepatologiske Forsøg, Lyngby, Denemarken

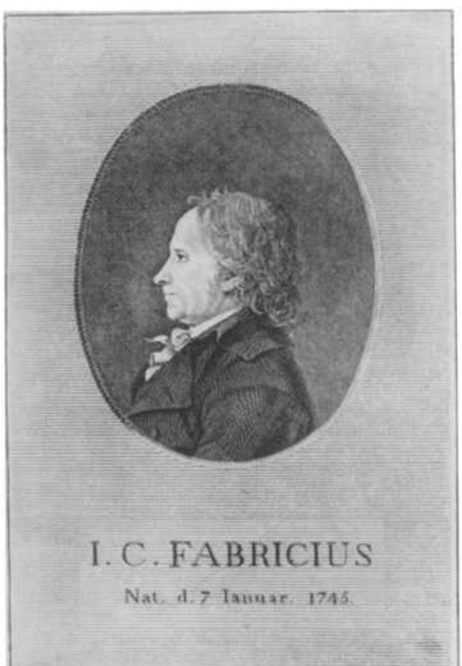

Fig. 1 *Photo K. Knoop*

Fig. 2 *Photo K. Knoop*

Fig. 3

Fig. 1. Noordeling from AS plot I without $MgSO_4$. July 3rd, 1950

Fig. 2. Noordeling from solution culture with 50mg Mn/L

Fig. 3. Noordeling from AS plot I, right with and left without $MgSO_4$, July 6th, 1951

Fig. 4. Eigenheimer from AS plot I, right with and left without $MgSO_4$, July 6th, 1951

Fig. 4

INJURY DUE TO EXCESS OF MANGANESE TO POTATOES[1])

BY

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For a number of years studies of manganese toxicity have been made in the experimental garden of the Laboratory for Microbiology at Wageningen (Löhnis 1946, 1950, 1951). Among plots (each 42 m^2) laid out in 1922 a triplicate series (termed in the following as I, II and III) of 6 plots each have been supplied with different amounts of ground limestone (60-30-15-10-5-0 kg). Two further plots in duplicate (termed as I and II) have either received ammonium sulphate or chilean nitrate as nitrogen fertilizer. Except for nitrogen all plots have received a similar manurial treatment each year and have been planted with the same crops, these, however, varying yearly.

From 1940 until 1948 half of each plot was planted with potatoes, but since 1949, the proportion has been $\frac{1}{3}$ of each plot only. On the remaining portion of each plot various crops have been tested for sensivity to excess of manganese, each year brown and snapbeans (Bruine en Dubbele prinsessebonen) being included.

In order to test whether magnesium deficiency played any part in the injury observed in acid plots, oats were grown in 1944 on the unlimed and ammonium sulphate plots. No signs of Mg deficiency were observed.

Since 1948 the potato varieties grown have been Eigenheimer and Noordeling. The latter is very prone to an injury, known among agriculturists as the „Noordeling phenomenon". While the plants are still in full growth the margins of the older leaves turn yellow and dark spots appear in the intervenal areas. These leaves are shed prematurely and while the upper part of the plant is still developing healthy leaves, the lower part may be defoliated. The eventual size of the plants is hardly or not at all affected. Field experiments have pointed to magnesium deficiency as the cause of this disorder. HEWITT (1944) induced similar symptoms in potatoes grown in sand culture lacking Mg. In solution cultures run by the writer (unpublished) Noordeling has shown these signs of Mg deficiency much earlier than Eigenheimer, thus proving its greater sensitivity.

On 10 June 1949 signs of Mg deficiency were recorded in Noordeling, most strongly in the ammonium sulphate plots, but markedly also in the unlimed ones. As time went on the symptoms were noted in all the plots. In 1950 and 1951 Mg deficiency in Noordeling occurred in increasing measure in all plots; Eigenheimer also showed the same symptoms, though in a lesser degree. It appeared that in course of time the Mg content of all the plots was decreasing, probably as a result of potassium magnesium sulphate, formerly used as potassium fertilizer, being out of the market. In 1949, as soon as the deficiency had appeared, on half the unlimed and ammonium sulphate plots planted with potatoes and beans, a top dressing with $MgSO_4$ was applied. For the potatoes the dressing proved too low to show any effect. On beans, however, the supply of $MgSO_4$ had a very curious effect. At the time of dressing the bean plants had shown very severe

[1]) Since 1948 this investigation has been carried out under the National Council for Agricultural Research, T.N.O. (Applied Scientific Research).

symptoms of Mn toxicity. In the halves of the plots treated with $MgSO_4$ plant development proceeded and signs of Mn excess could be noticed only on the older leaves. This is the usual course of events when the excess is slight. (Löhnis 1950, 1951). Where no $MgSO_4$ had been applied, the plants remained stunted, with severe symptoms of Mn excess all over the foliage. When the Mn content of the foliage was estimated in stored samples, it was found to be markedly lower in the better developed $MgSO_4$-treated plants than in the others. These experiments with beans will be described in further detail at a later date.

These observations on beans drew attention to a possible interrelationship between uptake of Mg and Mn by the plant. To arrive at a clearer understanding, in 1950 half of each unlimed and ammonium sulphate plot was supplied with $MgSO_4$ (at the rate of 170 kg/ha) at the time of seeding. The Mg deficiency symptoms had increased in all the plots, when compared with former years. In the unlimed and ammonium sulphate plots, however, the development of Noordeling was much better in the plot halves treated with $MgSO_4$; the same was true for Eigenheimer for unlimed plot I and both ammonium sulphate plots.

In the absence of $MgSO_4$, the plants not only remained markedly smaller, but some of them showed a very characteristic injury. Elongated, sunken, dark brown streaks appeared at the bases of the stems and later similar streaks appeared higher up the stems and at the insertions of the petioles. In the leaves minute dark spots appeared, which later coalesced, leading to collapse of the leaf tissue. The petioles showing dark streaks were very brittle and the leaves would drop at the slightest touch. The injury resembled a virus streak or a bacterial disease (Fig. 1). The same disorder has been noted in an unlimed field near Wageningen.

A description of a disorder with the above symptoms is to be found in a paper by BERGER and GERLOFF (1947). These authors studied a „stem streak necrosis" of potatoes occurring in acid fields in North Wisconsin. They ascertained that excess of Mn was the cause of the trouble and were able to reproduce the symptoms by growing potatoes in solution cultures supplied by 100 and 200 mg/L $MnCl_2$.

Van SCHREVEN (1939) induced symptoms of excess of Mn in potatoes by culturing them in nutrient solutions containing 400 mg/L and upwards of $MnSO_4 . H_2O$.

HEWITT (1947, 1948) induced the same disorder in sand cultures supplied with a nutrient solution containing 660 mg/L Mn.

Both these cases of experimentally induced symptoms of Mn toxicity agree closely with those occurring in the field in Wisconsin and at Wageningen.

For proving that excess of Mn was the real cause of the symptoms corrobation by means of solution cultures was needed. When a complete nutrient solution had 50 or 100 mg/L Mn as $MnSO_4.H_2O$ added to it, the characteristic lesions of the stems, nodes and petioles appeared and the foliage showed the dark spots, final disintegration and early shedding (Fig. 2).

Samples of the diseased plants from the Mg plot halves and of healthy plants from the corresponding + Mg ones were gathered on 30 June and stored for estimation of the Mn content. As it was already known that old leaves would contain more Mn than the top leaves, young and old leaves and the stems were gathered separately. In Table I the results of the chemical estimations are presented.

TABLE 1. 1950. Manganese ppm dry weight.

Plot	Ammonium Sulphate I and II		Unlimed I	
$MgSO_4$	–	+	–	+
Samples of:	*Noordeling*			
Stems	**2849**	1424	**1795**	1104
Young leaves	**1786**	1496	**1296**	1054
Old leaves	**3419**	2692	–	–
Samples of:	*Eigenheimer*			
Stems	**4273**	2251	**2991**	–
Young leaves	**3846**	1303	**1097**	1057
Old leaves	**5014**	3419	**1650**	1382

Figures in – $MgSO_4$ series exceeding the values in $+MgSO_4$ are given in bold-type.

All the plant parts from the –Mg plot halves had a higher content of Mn than corresponding parts from the + Mg plot halves. The difference was most marked in the parts most seriously injured.

In 1951, halves of all the experimental plots were supplied with $MgSO_4$ (170 kg/ha). The Mg deficiency was very conspicuous in Noordeling as well as in Eigenheimer and eventually in all plots; even in the halves which had been supplied with $MgSO_4$, severe Mg deficiency occurred. In the latter halves, even in the most acid ones, the development in height, however, remained unimpaired and only an early shedding of the leaves due to Mg deficiency prevailed. In both ammonium sulphate plots, the plants in the -Mg halves, Eigenheimer as well as Noordeling, remained much smaller from the start (4 June). At a later date in many of these small plants the characteristic lesions in stems and leaves were observed. In the unlimed plots a smaller difference in development was recorded on 20 June and only in the -Mg half of plot III were slight symptoms of Mn injury noted on 7 July. At that date most plants of the -Mg half of the ammonium sulphate plot I were very seriously injured. In the ammonium sulphate plot II, somewhat shaded by neighbouring trees, plants lagged in development and stem lesions appeared somewhat later.

Samples were gathered in corresponding +Mg and –Mg plots and the results of chemical estimations are presented in Table II.

Table II. 1951. Manganese ppm dry weight

Plot	Ammnium sulphate												Unlimed					
	I						II						I		II		III	
Sampling date	6/6		29/6 [1]		6/7 [2]		6/6		29/6 [3]		28/7 [4]		6/6		6/6		6/6	
MgSO4	–	+	–	+	–	+	–	+	–	+	–	+	–	+	–	+	–	+
Samples of:	*Eigenheimer*																	
Stems	–	–	**2778**	1923	**2564**	1701	–	–	**1328**	937	**2528**	1674	–	–	–	–	–	–
Young leaves	**1417**	1118	**3575**	2058	2243	2566	1122	1168	**1922**	1709	1503	1745	**543**	505	448	559	**801**	532
Old leaves	–	–	**2749**	1887	–	–	–	–	1424	2137	–	–	–	–	–	–	–	–
Samples of:	*Noordeling*																	
Stems	–	–			**4548**	2172					**3418**	2386						
Young leaves	**1119**	838			2706	3045					**2268**	1460						

[1]) Stem lesions
[2]) Photo's 3 and 4
[2]) No stem lesions
[4]) Stem lesions

Figures in -MgSO4 series exceeding the values in + MgSO4 are given in bold-type.

Here again the Mn content in stems from the –Mg plot halves was found to be much higher than in the healthy plants from the +Mg halves. For the leaves this was not always the case, but in plants such as those in Figs. 3 and 4, where there was serious injury at the bases of the stems any abundant transport of Mn to the leaves is hardly to be expected.

DISCUSSION

Until 1950 potatoes had shown no visible injury in plots where more sensitive crops such as beans and lucerne had suffered seriously from excess of manganese, although the Mn content of the potato foliage had often surpassed the level dangerous for other crops (Löhnis, 1950, 1951). In the last two years conditions allowed the onset of toxicity symptoms, and this was found to be due to a much higher uptake of Mn, coupled with decreasing availibility of magnesium.

The rise of the Mn level in the plants on Mg-deficient soil might be due to various causes. The Mg might affect the quantity of available Mn in the soil. In 1950 some data were collected on the amount of exchangeable Mn in corresponding half-plots, but it was not possible to detect any tendency for exchangeable Mn to exceed that in the +Mg ones. It is intended, however, to collect further data.

An influence of Mg on the uptake of Mn by the plants seems more probable. Antagonostic action of heavy metals, more especially of iron, to Mn has often been ascertained experimentally. As in the usual type of soils the solubility of both Mn and iron will increase under acid conditions, an increase in the uptake of Mn due to a low supply of iron is hardly to be expected under agricultural conditions.

HEWITT (1946, 1947) in sand cultures found that there was a reduction in the uptake of Mn in the presence of soluble Ca. Both factors, low Ca and high Mn, might easily occur side by side in acid soils, the latter inducing a higher content of Mn in the crop.

SCHMEHL, PEECH and BRADFIELD (1950) were able to corroborate this in some measure by experiments in soil.

In the same way, in acid soils the Mg may be expected to be low with a high level of available Mn.

The only case that has come to my notice of an effect of Mg on the uptake of Mn being reported is one by PARBERRY (1943), who investigated a „scald" on beans on certain soils in New South Wales. The affected plants had a higher content of Mn, more especially those which were deficient in Mg.

The beneficial effect of fertilizing potatoes in acid soils with Mg salts may be due to correction of Mg deficiency, but it may also be due to reduction of injury due to excess of Mn.

SUMMARY

Potatoes grown in acid soils suffered injury due to excess of manganese.

The uptake of manganese by the plants was influenced by the amount of available magnesium present.

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KEIMUNGSTEMPERATUR UND FLUGBRANDBEFALL

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Nach OORT (Tijdschrift over Plantenziekten 50, 73–106, 1944) ist das Zustandekommen der Flugbrandinfektion, insbesondere das Vordringen des Brandpilzes in den Keimling der heranwachsenden Samenlage, an genügend hohe Temperaturen während der Entwicklung und der Reifevorgänge des Kornes gebunden; denn durch niedere Temperaturen wird der Infektionserfolg nachweislich herabgesetzt. Andererseits ließen weitere Versuche des gleichen Autors insoweit keinen Einfluß der Temperatur auf den Flugbrandbefall erkennen, als die Temperatur während der Keimung und auch die späteren Temperaturverhältnisse die Höhe des Brandbefalls nicht zu beeinflussen vermochten.

Die folgenden Versuche befassen sich mit dem Einfluß der *Keimungstemperatur* auf den Flugbrandbefall. Die an heranwachsenden Getreidekörnern gemachten Feststellungen von OORT lassen sich dahin deuten, daß die Entwicklungs- und Wachstumsbedingungen von Brandpilz und Wirtspflanze an verschiedene Kardinalpunkte der Temperatur gebunden sind. Wenn dies richtig ist, muß trotz der entgegengesetzten Feststellungen von OORT mit der Möglichkeit gerechnet werden, daß auch bei der Keimung ähnliche Beziehungen zwischen Keimungstemperatur und Brandbefall vorliegen wie sie OORT für das Infektionsverhalten der Brandpilze in den sich entwickelnden Samenanlagen feststellen konnte. Von diesem Gesichtspunkt ausgehend, ist im folgenden die Frage geprüft, ob und inwieweit tiefe Temperaturen während des ersten Keimungsablaufs der Getreidekörner den Flugbrand zu beeinflussen vermögen.

Die *Versuchsanstellung* in den 3 im folgenden mitgeteilten Hauptversuchsreihen (Tab. 1–3) sowie in 2 weiteren, hier nicht wiedergegebenen, aber zu