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INSTITUTT FOR JORD- OG VASSFAG

DEPARTMENT OF SOIL AND
WATER SCIENCES

COMPARISON OF MANGANESE EFFECTS OF SEMANOX AND MANGANESE SULPHATE IN RELATION TO YIELD AND DEVELOPMENT OF OATS.

Av
Ivar Aasen

Rapport nr. 9/2001 (99)

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The first year, at all Mn-rates compared, Semanox proved more effective as a Mn source than Mn sulphate. The second year, only the highest rate of Mn gave a satisfactory yield; the last two years, however, the Mn supply was too low even at the highest rate, whether it was applied in form of Semanox or in form of Mn sulphate.

A comparison of Semanox and Mn sulphate at the highest Mn rate, and for the whole 4-year period, showed no significant yield differences.

Semanox incorporated in the soil has also been tested in field trials on Mn-deficient silt loam (pH 6.1-7.1). Test crops have been small grains. Compared with Mn sulphate no significant yield differences were found. In these trials only leaf fertilisation with Mn sulphate gave satisfactory yield responses.

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1. Semanox
2. Mangansulfat
3. Sandjord
4. Havre
5. Mn-opptak

Emneord, engelske

1. Semanox
2. Manganese sulphate
3. Sandy soil
4. Oats
5. Mn-uptake

Prosjektleiar:

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Ivar Krogstad

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Tore Krogstad

Forord

I åra 1966-69 vart det ved daverande Institutt for jordkultur, NLH, utført vekstforsøk med eit finpulverisert mangangjødselmiddel med namnet Semanox. Semanox inneheld 54 % mangan som MnO. Midlet er levert av firmaet S. C. des Mines, Minerais et Metaux, Belgia, og forhandla her i landet av Alf Axelsen A/S, Oslo. Alf Axelsen A/S har vore vår kontakt gjennom heile forsøksperioden.

Rapport med førebels forsøksresultat vart sendt Alf Axelsen A/S etter 2. og 3. forsøksåret. Ein sluttrapport som omhandlar alle fire åra, vart sendt i februar 1970. Denne rapporten var skriven på engelsk. Noko vidare publisering av forsøksresultata vart ikkje gjort.
For at dette materialet ikkje skal gå tapt for instituttet, blir denne rapporten no utgitt i rapportserien til Institutt for jord- og vassfag, NLH.

Da sluttrapporten vart skrive i februar 1970, var dei kjemiske avlingsanalysane frå det siste forsøksåret enno ikkje ferdige. Avlingsanalysane frå heile forsøksperioden er no stilt saman og kommentert i eit vedlegg bakarst i rapporten.

Institutt for jord- og vassfag, NLH, desember 2001

Ivar Aasen

COMPARISON OF MANGANESE EFFECTS OF SEMANOX AND MANGANESE SULPHATE IN RELATION TO YIELD AND DEVELOPMENT OF OATS.

Ivar Aasen
The Agricultural College of Norway [1]

The manganese effects of Semanox [2] (about 54 per cent Mn as MnO) and manganese sulphate ($MnSO_4 \cdot H_2O$, 32.5 per cent Mn) have been studied in a pot experiment with oats (F 14/66). The experiment covered four years, from 1966 to 1969. The present report gives the main results from the experiment.

Materials, methods, and treatments

Pots: Enamelled iron pots, 20 cm deep, and with a capacity of 5 litres each.

Soil: Sandy soil with about 4 per cent of organic matter, 1.8 ppm of active Mn, and pH (H_2O) 7.8.

Amount of soil per pot: 5.5 kg of soil dry matter.

The basal dressing per pot was as follows: 5.058 g $Ca(NO_3)_2 \cdot 4H_2O$, 0.610 g $Ca(H_2PO_4)_2 \cdot H_2O$, and 1.337 g K_2SO_4. In addition were given 1.25 g $MgSO_4 \cdot 7H_2O$, 0.125 g $CuSO_4 \cdot 5H_2O$, 0.0125 g $Na_2B_4O_7 \cdot 10H_2O$, and 0.0025 g $(NH_4)_6Mo_7O_{24} \cdot 4H_2O$.

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1) Institute of Fertilization and Soil Management

2) Supplied by Alf Axelsen A/S., Oslo

The experimental fertilizers applied the first year are shown in Table 1.

Table 1. Treatments, rates of manganese, and fertilizers

Treatment		Manganese added, mg per pot	Fertilizers
a	Control	0	None
b		33.75	Semanox
c		33.75	$MnSO_4 . H_2O$
d		67.50	Semanox
e		67.50	$MnSO_4 . H_2O$
f		337.50	Semanox
g		337.50	$MnSO_4 . H_2O$

The rates of manganese added correspond to 0, 25, 50, and 250 kg of Semanox per hectare.

The following years, only basal dressings were given. The purpose of the experiment these years was to measure the residual effect of the manganese fertilizers applied the first year.

All chemicals used, except Semanox, were reagent grade.

There were three replications of each treatment. Distilled water was added up to 60 per cent of the maximum water capacity of the soil.

Oats (Sol II) was used as test crop. After emergence, the number of plants per pot was regulated to a total of 14.

Planting and harvesting dates were as follows:

Year	Planting	Harvesting
1966	May 12	August 16
1967	May 23	September 1
1968	April 26	August 7
1969	April 25	August 4

The experiment continued for two years with no change of treatment; in 1968, however, only Treatments a, f, and g were continued.

The last experimental year (1969), in order to obtain an additional treatment with a satisfactory supply of manganese, one replication from Treatments f and g were mixed thoroughly and then divided into two equal portions, forming Treatment j. To this treatment, prior to planting, and in addition to the basal dressing, was added 337.5 mg of manganese as $MnSO_4.H_2O$ per pot. Later in the growing season, the plants in this treatment were sprayed three times with a 2-per cent solution of $MnSO_4.H_2O$, at the rate of 1 ml per pot, which corresponds to 318 litres per hectare, per spraying. The spraying times were 3, 5, and 7 weeks after planting, resprectively. Thus, in 1969, the experiment comprised four treatments: a, with three replications, and f, g, and j, with two replications each.

Results and discussion

The results from the first two years of the experiment are shown in Table 2.

Table 2. Yield, grain percentage, and manganese deficiency records in 1966-67

Treatment	Yield (air-dry), g per pot				Grain percentage		Manganese deficiency recorded just before earing x)	
	Grain + straw		Grain					
	1966	1967	1966	1967	1966	1967	1966	1967
a Control	39.6	30.2	1.1	13.2	2.9	43.7	5	4
b 33.75 mg Mn as Semanox	66.7	31.6	33.0	13.8	49.5	43.8	2	3
c 33.75 mg " " $MnSO_4.H_2O$	54.7	32.6	23.4	14.8	42.8	45.3	3	3
d 67.50 mg " " Semanox	74.7	35.1	36.6	17.0	49.0	48.5	0	2
e 67.50 mg " " $MnSO_4.H_2O$	65.9	35.7	32.6	15.2	49.5	42.7	1	2
f 337.5 mg " " Semanox	76.7	42.4	36.6	21.7	47.7	51.3	0	0
g 337.5 mg " " $MnSO_4.H_2O$	71.0	50.1	34.2	23.6	48.2	47.1	0	1
LSD 5 % (control omitted)	4.7	8.3	3.3	5.0				

x) 0 = No deficiency, 5 = very heavy deficiency

The first experimental year (1966), Semanox was a more effective manganese source than manganese sulphate. Maximum yield of grain was obtained at a manganese rate of 67.5 mg per pot when Semanox was applied (d), while more manganese seemed to be required when manganese sulphate was used. Without a manganese supply, the grain yield was almost a failure. These results corresponded very well with the deficiency symptoms recorded.

The second year (1967) shows a somewhat altered picture, the yield obtained in treated pots being considerably lower than that of the first year, while the control shows an essentially higher yield. It is possible that some of the manganese originally present in the soil was converted into available forms during winter (the soil was allowed to dry out during storage). On the whole, however, most of the manganese added the first year appears to have been converted into unavailable forms. Only the highest rates of manganese (f and g) produced a comparatively satisfactory yield response. No significant yield diffierences between Semanox-treated and manganese sulphate-treated pots were found this year.

Symptoms of manganese deficiency developed in all treatments except at the highest rate of Semanox (f). At the highest rate of manganese sulphate (g), only weak deficiency symptoms were detected.

The third year (1968), only the control and the highest rates of Semanox and of manganese sulphate (a, f, and g) were continued. Manganese deficiency developed in all treatments. Unfortunately, no treatment with an adequate supply of manganese was included this year. Therefore, the yield reduction due to manganese deficiency cannot be fixed. The Semanox treatment showed a minimum of deficiency symptoms and yielded almost twice as much grain as the manganese sulphate treatment (Table 3).

Table 3. Yield, grain percentage, and manganese deficiency records in 1968-69

Treatment	Yield (air-dry), g per pot				Grain percentage		Manganese deficiency recorded just before earing x)	
	Grain + straw		Grain					
	1968	1969	1968	1969	1968	1969	1968	1969
a Control	21.9	34.6	2.2	12.3	10.0	35.7	5	5
f 337.5 mg Mn as Semanox	59.5	46.2	29.3	22.5	49.2	48.6	2	4
g 337.5 mg " " $MnSO_4.H_2O$	43.0	48.0	15.8	25.0	36.7	52.1	4	3
j 337.5 mg " " " + leaf spraying		58.7		29.8		50.8		0
LSD 5%	7.1	8.7	3.1	4.1				

x)
See notes under Table 2.

The fourth year (1969) Semanox-treated pots (f), showed a heavier manganese deficiency, and gave a numerically lower yield, than manganese sulphate-treated pots (g), see Table 3. However, the yield difference between these two treatments was not significant.

The plants in Treatment j developed without any indications of manganese deficiency, and the yield was significantly higher than those of Treatments f and g.

These results show that the effect of a high rate of manganese, mixed with the soil, diminishes with time, the yields obtained the fourth year after application were unsatisfactory for Semanox as well as for manganese sulphate.

Table 4. Yield, grain percentage, and 1,000-kernel weight. Mean for 1966-69

	Control	337.5 mg Mn per pot		LSD
		Semanox	$MnSO_4 \cdot H_2O$	
	a	f	g	5%
Grain + straw, g per pot	31.6	56.2	53.0	13.8
Grain, g per pot	7.2	27.5	24.7	13.0
Grain percentage	23.1	49.2	46.0	18.8
1,000-kernel weight	28.1	30.3	29.8	3.5

Table 4 shows mean values for the treatments that were continued throughout the experiment. As an average, the highest manganese supply has given a significantly higher yield and a significantly higher grain percentage than the control, while no significant differences were found in the 1,000-kernel weight.

As an average for the whole period, no significant differences between Semanox and manganese sulphate were found as to the effect on yield, grain percentage, or 1,000-kernel weight. However, the first year, at all rates of manganese, Semanox proved a more effective manganese source than manganese sulphate.

At present, nothing definite can be said about the manganese uptake, as the chemical analyses have not been completed as yet.x) But the manganese content in the first years's crop seems to indicate a higher manganese uptake for Semanox than for manganese sulphate.

x) See Appendix Table 6 and 7.

As will be known, oats is able to absorb and tolerate high levels of manganese. The first experimental year, the manganese concentrations in mature plant dry matter were 16.8 and 14.0 ppm for the greatest application of Semanox and manganese sulphate, respectively. These concentrations are unexpectedly low, being far under the tolerance level found for high manganese sensitive cereal varieties. These findings indicate that, relatively soon after being mixed with the soil, a high proportion of the manganese added, in form of Semanox as well as manganese sulphate, was converted into low available forms. No injurious effects of the highest rate of manganese were detectd.

Table 5. Manganese deficiency recorded just before earing.[x)]

Treatment	1966	1967	1968	1969	Mean
a Control	5	4	5	5	4.8
f 337.5 g Mn as Semanox	0	0	2	4	1.5
g 337.5 g " " $MnSO_4 \cdot H_2O$	0	1	4	3	2.0

x) See notes under table 2.

At the highest level of manganese, manganese deficiency symptoms increased with time (Table 5). During the first three years, Semanox proved more effective in preventing deficiency symptoms than did manganese sulphate (see also Table 2.) In the fourth year, however, the deficiency symptoms were at least as severe for Semanox as for manganese sulphate.

Summary and conclusions

The manganese effects of Semanox (about 54 per cent Mn as MnO) and manganese sulphate ($MnSO_4.H_2O$, 32.5 per cent Mn) were studied over a 4-year period in a pot experiment with manganese-deficient sandy soil with pH (H_2O) 7.8. Oats (Sol II) was used as a test crop. The manganese fertilizers were applied at the beginning of the experiment at the rate of 0, 33.75, 67.5, and 337.5 mg of manganese per pot.

The first year, at all manganese rates compared, Semanox proved more effective as a manganese source than manganese sulphate. The maximum yield of grain was reached at a rate of 67.5 mg of manganese per pot for Semanox, while for manganese sulphate, a higher level seemed to be required.

The second year, only the highest rate of manganese gave a satisfactory yield; the last two years, however, the manganese supply was too low even at the highest rate. Nevertheless, in the three years following the manganese application, there was a marked yield response to the highest level of manganese, whether it was applied in form of Semanox or in form of manganese sulphate.

A comparison of Semanox and manganese sulphate at the highest manganese rate, and for the whole 4-year period, showed no significant differences.

No injurions effects of the highest rate of manganese were detected.

February 26, 1970

Ivar Rasen.

Tabell 6. Tørrstoffavling (korn + halm), mangankonsentrasjon, og opptatt mangan i avling

Ledd [1] / år	Korrigert loavling, g tørrstoff per kar				Mangan i lo, mg per kg tørrstoff				Opptatt mangan i loavling, mg per kar			
	1966	1967	1968	1969	1966	1967	1968	1969	1966	1967	1968	1969
a	36,7	28,0	20.0	33,2	3,98	5,39	7,11	5,42	0,146	0,151	0,142	0,180
b	61,4	28,9			4,92	5,46			0,302	0,158		
c	50,4	30,2			3,77	6,47			0,190	0,195		
d	68,6	32,4			6,28	6,49			0,431	0,210		
e	60,6	32,6			4,89	7,66			0,296	0,250		
f	70,6	38,9	54,7	44,4	16,79	13,07	7,94	4,68	1,185	0,508	0,434	0,208
g	65,4	46,4	39,6	46,1	13,96	6,48	6,41	4,58	0,913	0,301	0,254	0,211
j				56,4				120,0				6,768

1) Sjå tabell 2 s. 3 og tabell 3 s. 5.

Tabell 7. Opptatt mangan av tilført (b ... g) – a [1]

Ledd / år	Mg Mn per kar					Prosent
	1966	1967	1968	1969	Sum	
b	0,156	0,007			0,163	0,48
c	0,044	0,044			0,088	0,26
d	0,285	0,059			0,344	0,51
e	0,150	0,099			0,249	0,37
f	1,039	0,357	0,292	0,028	1,716	0,51
g	0,767	0,150	0,112	0,031	1,060	0,31
j				6,588	6,588	

1) Sjå tabell 6.

I tabell 6 er vist tørrstoffavling av lo, mangankonsentrasjon i lo, og opptatt mangan i loavlinga for kvart forsøksår. Andre året (1967) merkar seg ut med mykje mindre avling enn første året. Dette kan til ein viss grad skuldast oksidering av manganpreparata som var innblanda i jorda ved starten av forsøket og dermed sterkare manganmangel. Ei anna årsak kan vera den seinare såtida andre året (sjå tabellen nedst på side 2 i rapporten) og dermed den høgare temperaturen i første delen av veksttida. Summen av middeltemperaturane dei første fire vekene etter såing var 106 grader høgare i 1967 enn i 1966. Dette kan ha ført til for rask utvikling av plantene. Den viktigaste årsaka er truleg eit åtak av mjøldogg som reduserte den friske bladmassen sterkt.

Mangankonsentrasjonen i plantene ved største tilførsel (ledd f og g) har minka sterkt dei to siste åra og aller sterkast siste året. Dette tyder på at mesteparten av manganet som var innblanda i jorda første året, er overført til former som plantene ikkje greier å ta opp gjennom røtene.

Kor mykje av det tilførte manganet i gjødsla som er tatt opp i plantene, kan ikkje reknast ut heilt nøyaktig. Men dersom ein føreset at det opptatte manganet i kontrolleddet (a) svarar til det som er tatt opp frå jorda i dei gjødsla ledda, så kan ein få eit mål for det som er tatt opp frå gjødsla med å trekka opptatt mangan i ledd a frå opptatt mangan i dei gjødsla ledda. Dette er gjort i tabell 7. På dette grunnlaget er det i tabell 7 også vist kor stor prosent av tilført mangan som er tatt opp i plantene. Opptaket frå Semanox er størst, om lag 0,5 prosent av tilført, medan det frå mangansulfat er tatt opp 0,21-0,37 prosent. I tillegg til dette kjem det som er tatt opp i stubb og røter, men som ikkje er tatt med her.

Siste året (1969) var det med eit ledd med bladgjødsling med mangan (ledd j). På dette leddet viste plantene ingen synlege symptom på manganmangel. Dette leddet gav størst avling både av lo og korn og hadde høgast konsentrasjon av mangan i loavlinga. Ein kan likevel ikkje sjå bort frå at litt av manganet i loavlinga kan vera eit utvendig belegg på blad og strå. Det verkelege opptaket treng såleis ikkje vera fullt så stort som analysen viser. Likevel kan ein slå fast at bladgjødsling med mangan er meir effektivt enn innblanding i jorda der ein har for knapt innhald av plantetilgjengeleg mangan i jorda.

Semanox har også vore samanlikna med mangansulfat til korn i feltforsøk. Både siltjord og lettleire har vore representert, og pH har variert i området 6,1-7,1. Kontrolledda utan mangantilførsel har vist klare symptom på manganmangel. Innblanda i jorda har både Semanox og mangansulfat som regel gitt ein liten avlingsauke første året, men ingen sikker skilnad mellom desse to midla er påvist. Bladgjødsling med mangan har også i desse forsøka gitt sikker avlingsauke og stått klart betre enn innblanding i jorda.