

146. MOLYBDENUM IN RELATION TO NITROGEN FIXATION
OF LEGUMINOUS CROPS

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The effect of molybdenum on nitrogen fixation by leguminous plants was studied by the author in culture-solution experiments with peas (3). Although in the absence of molybdenum as well as in the complete nutrient solution many nodules developed on the pea roots, the nitrogen fixation in the former case was very poor, resulting in an inadequate nitrogen supply to the plants. Pronounced nitrogen-deficiency symptoms were seen and the plants died at an early stage.

In order to know whether or not molybdenum deficiency might occur in leguminous plants growing on Dutch soils, field experiments with peas were carried out on soils on which pea growth was poor. The soils used in these experiments were clay soils with a slightly alkaline reaction and slightly acid sandy soils. No response to molybdenum was observed in these experiments. In some cases boron appeared to be the limiting factor of nitrogen fixation (4).

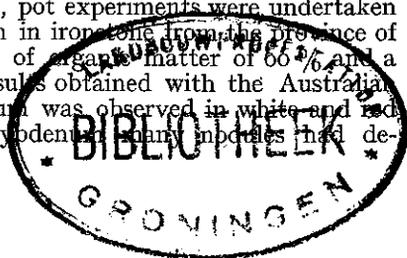
Some years later pot experiments were carried out with soils poor in available molybdenum received from Australia by courtesy of Professor PRESCOTT, Waite Institute, Adelaide. These soils were rich in ironstone and slightly acid. A clear response to molybdenum was found in white clover and in subterranean clover growing on these soils (Table I). Without application of molybdenum the colour of the clover leaves was yellow-green due to nitrogen deficiency. Supplied with 5 mg $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ per pot (containing about 2 kg of soil) the colour was dark green. Peas growing on these soils did not respond to molybdenum.

TABLE I. Effect of an application of molybdenum on nitrogen fixation and yield of clovers grown on Australian soils.

Soil from	pH of soil	$\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ applied per pot (2 kg of soil)	White clover		Subterranean clover	
			Dry weight, g per pot	Nitrogen in plants per pot, mg	Dry weight, g per pot	Nitrogen in plants per pot, mg
Tasmania . .	6.2	0	4.2	110.5	12.9	272.0
" "	"	5	12.2	382.0	16.8	428.5
S. Australia .	5.2	0	4.3	93.4	11.1	243.0
" "	"	5	5.9	170.0	17.3	395.0

Experiments with Dutch soils.

Since the Australian soils used in these experiments were rich in ironstone and rather acid, (see Table I), pot experiments were undertaken with an acid lowmoor peat soil rich in ironstone from the province of Groningen. This soil had a content of organic matter of 66% and a pH of 5.0. In agreement with the results obtained with the Australian soils a great response to molybdenum was observed in white and red clover. Without application of molybdenum many nodules had de-



veloped in both plant species. These nodules were smaller than those of plants supplied with molybdenum, whereas the colour was not pinkish as usual but yellow or brown-gray. Nitrogen fixation was quite inadequate, as a result of which the plants became pale green and grew much poorer than those supplied with traces of molybdenum. With improving supply of molybdenum the number of nodules decreased but their nitrogen-fixing capacity increased considerably (Table 2).

As will be seen from Table 2, optimal nitrogen fixation of white clover was attained already at 100 γ $\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ per pot. With higher gifts nitrogen fixation was only slightly changed. The molybdenum content of the plant tissue rose considerably, however. Since it is a well-known fact that a molybdenum content of the herbage of 20 mg per

TABLE 2. Effect of applications of molybdenum on nitrogen fixation and yield of white clover grown on an acid lowmoor peat soil rich in ironstone.

$\text{Na}_2\text{MoO}_4 \cdot 2\text{H}_2\text{O}$ applied per pot x) γ	Dry weight, g per pot ⁺)	Nitrogen in plants, per pot, mg ⁺)	Number of nodules per 173 cm ² bot- tom of glass cylinder ⁺)	Molybdenum in plants, mg per kg of dry matter ⁺)
0	2.1	51.6	456	< 1.0
10	2.7	71.7	368	1.8
50	4.1	131.0	254	2.4
100	4.7	152.0	151	3.7
500	4.8	158.7	87	4.3
1000	4.8	155.0	116	3.3
2500	4.7	150.0	123	6.5
5000	4.6	147.9	116	13.7
10000	4.8	151.0	107	25.4
20000	3.8	127.0	109	80.0
50000	4.4	147.0	70	183.1

x) each pot contained about 500 g of soil.

+) averages of duplicate values.

kg of dry matter may cause cattle-poisoning, care should be taken that these values will not be reached.

With red clover similar results were obtained on this soil. Peas and beans (*Phaseolus*) did not respond to molybdenum. With both plant species a normal nitrogen fixation was obtained with no application of molybdenum. It is unknown whether this was due to the higher molybdenum supply to the plants from the seeds or from their capacity to absorb less available soil molybdenum.

Experiments with acid sandy soils. Responses to molybdenum in white clover were also observed on a number of acid sandy soils with pH-values varying from 4.2—4.9. The difficulty here was that, independently of molybdenum supply, nodulation was much depressed by an acid soil reaction. Once nodules had developed, however, a clear stimulation of nitrogen fixation was observed when molybdenum had been supplied to the plants. Apparently availability of soil molybdenum is

much reduced by a low pH of the soil. This conclusion is in agreement with results obtained by JENSEN (2) with molybdenum-deficient soils and by FERGUSON *et al.* (1) in pasture experiments on soil rich in molybdenum.

Estimation of plant-available molybdenum.

For these tests the fungus *Aspergillus niger* may be used. This organism requires traces of molybdenum when cultivated in a solution supplied with nitrate nitrogen. In the absence of available molybdenum growth is very poor and yields are low. With improving molybdenum supply both yield of mycelium and sporulation increase considerably. This fact may be used for the microbiological assay of available molybdenum in soil (see (3) and (5)).

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