

## NITROGEN DRESSING IN ORCHARDS WITH A GRASS SWARD

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### INTRODUCTION

Soil management systems in which the orchard soil surface is covered during the greater part of the year or even permanently, offer distinct advantages for modern fruit plantations.

The *permanent grass sward* is generally looked upon as the ideal method of soil management as far as the soil structure and the passableness are concerned. It implies, however, a rather severe competition for nutrients and moisture. In this report some results are given of experiments in which this competition was studied.

### EXPERIMENTS

A. In 1955 an experiment was started in a six years old orchard planted with the variety Jonathan on M. VII, on river deposit clay soil. The grass sward was two years old and the treatments were clean cultivation with autumn weed, grass with a low and high mowing frequency (four and eight times a year respectively). Half of the plots was irrigated by sprinkling, each plot being divided in four subplots receiving nitrogen at a rate of 25, 100, 175 and 250 kg per ha respectively.

B. Nitrogen was applied at 6 or 7 different dates during the winter seasons 1957-1958 and 1958-1959 in an orchard with a grass sward on a marine loamy clay soil. The penetration into the profile was followed by periodic sampling of the soil at various depths and determination of the content of water-soluble nitrogen using the technique described by HARMSEN (1961).

C. In two experimental fields on river deposit clay soil the nitrogen was applied at various dates during the winter seasons 1959-1960 and 1960-1961 and the effects on the trees were studied.

D. A 5.7 % solution of ammoniumnitrate was injected at a depth of 15-30 cm at a rate of 20.000 injection-points per ha. Each injection consisted of half a liter of the solution. The points were divided over the whole plot area and were spaced 70 cm in the direction of the rows and 100 cm between the rows, the smallest distance to the tree stem amounting to 70 cm.

E. In another experiment nitrogen was applied in bands parallel to the treerows at a depth of 10-15 cm, the distance to the trees being 70 cm and between the bands 100 cm.

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### EFFECTS OF GRASS SWARD VERSUS CLEAN CULTIVATION

The soil on the plots with clean cultivation from April to August and weedgrowth afterwards (exp. A) clearly showed a deterioration of the structure especially in the 0-20 cm layer. This surface layer is compacted in comparison with the soil on the grass plots: the pore volume decreased to 42,8 % for the 0-10 cm layer against 48,2 % on the grass plots.

The percentage of water stable aggregates also decreased. Similar observations are reported by GOODE (1958).

The better soil fauna under the sward will contribute to the maintenance of a good structure. In 1960 25 earthworms per m<sup>2</sup> were found on the cultivated plots, against 385 per m<sup>2</sup> for the long grass and 260 per m<sup>2</sup> for the short grass (VAN RHEE and NATHANS 1961).

The trees showed a better vigour on the cultivated plots during the first years of the experiment. This may be caused partly by the breaking of the young grass sward, which is known to release nutrient elements especially nitrogen. After the third year the vigour of the trees on the cultivated plots showed a gradual decline. A rather severe increase of canker infestation and iron chlorosis symptoms appeared in the autumn of 1960 after a wet summer. This unfavourable development was even more pronounced in the next year when the summer season was also very wet.

After the first years the differences in yields decreased and in 1961 a higher yield was obtained from the trees on the permanent sward (see table 1).

TABLE 1. — Relative yields for clean cultivation and more and less frequently mown grass on river deposit clay soil (average yield pro year = 100 %)

	Trial year	Clean cultivation	Long grass	Short grass
1955	1 th	101	95	104
1956	2	133	82	85
1957	3	154	74	72
1958	4	122	93	85
				grass in strips
1959	5	98	99	103
1960	6	103	96	101
1961	7	95	111	94

### INFLUENCE OF MOWING FREQUENCY

The differences in yield on the plots with long and short grass are small. Obviously the decrease in competition due to frequent cutting was not of any importance in this case. Similar results were obtained in our other experiments. The grass sward was rather heavy in this case, consisting mainly of *Poa trivialis* and *Poa pratensis*. No significant differences in nitrate and moisture content were found with the two different mowing regimes. GOODE (1956), however, has found this significant.

In 1959 the short grass treatment was changed in a cultivated strip of 70 cm on both sides of the tree rows and grass strips between these rows. According to BUTIJN and WIERSEMA (1959) the uptake of nitrogen by the tree may be equal to that on clean cultivated soils, whereas the advantage of a protection between the rows remains in respect to the passableness. In our experiment the nitrogen content of the leaves improved, but did not yet reach the nitrogen level of the trees on the cultivated soil in 1961. In a dry season the moisture content of the soil was much higher in the cultivated strips than under the sward.

NITROGEN UPTAKE OF THE GRASS

The production of dry matter by the grass sward is influenced by the mowing frequency (Table 2) (POUWER, 1957).

TABLE 2. — Influence of mowing frequency on production of grass

Mowing frequency pro year	Length of grass	Production (kg dry weight pro ha)
12 ×	5 cm	3500
6 ×	10	6000
3 ×	20	5500
2 ×	30	4000

The grass will take up a large amount of nutrients. At an annual production of 6.000 kg per ha an amount of 150 kg of nitrogen can be fixed in the overground plant parts.

The nitrogen will also be taken out of circulation due to the formation of humus. Thus in young orchards an increase of 1 % or more organic matter is found in the 0-20 cm layer over a period of ten years after the grassing down (POUWER, 1960). This means an annual increase of 2.500 kg of organic matter and at a C/N = 12 an annual intake of 125 kg of nitrogen per ha. Under a grass sward of more than 15 years the content of organic matter does not change much. After grassing down a young orchard much higher nitrogen dressings are necessary than in older orchards. After sowing the grass in an orchard planted on arable land a dressing of 350 or more nitrogen pro ha is needed during the first years : 50 kg for the tree, 200 kg for the grass sward and 125 kg for building up organic matter. The C- and N-content of the 0-5 and 5-20 cm layers may give a fair estimate of how much the building up of the organic matter has progressed. According to POUWER (1960) nitrogen deficiency can be expected with a total nitrogen content lower than 0,2 % and a C/N ratio higher than 15.

SOIL AND LEAF ANALYSIS FOR NITROGEN UNDER GRASS AND CULTIVATION

The content of water soluble nitrogen will be higher on a clean cultivated soil during a greater part of the growing season than under a grass sward (see table 3) (DALBRO 1958). No large differences were found between the treatments with long and short grass.

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TABLE 3. — Nitrate content under clean cultivation, long and short grass in the layer 0-20 cm (1956). Time of dressing late February

	NO <sub>3</sub> - N 25 kg N/ha			p. p. m. 250 kg N/ha		
	data 5/30	6/22	7/4	5/30	6/22	7/4
clean cultivation	8	4	2	24	15	6
long grass	0	1	0	6	3	1
short grass	0	2	1	6	7	6

Periodic sampling of the whole root zone would be a reliable method for establishing the amount of available nitrogen and the N-requirements (HARMSSEN, 1961). This method however is too laborious for practical advices on nitrogen dressing.

The nitrogen content of apple leaves sampled in August of the third year of experiment A, was higher and showed less variation at the various nitrogen levels on the clean cultivated plots (2,33 to 2,38 %) than on the grass plots (2,07-2,38 %). In the later years of this experiment the differences tended to be lower, showing that the competition of the grass sward became less severe. There was a tendency also, in dry years, for the nitrogen content of the leaves to increase less by dressing. The observation that the nitrate content of the soil remains higher confirms this indirectly.

### DECREASE IN COMPETITION OF THE GRASS SWARD

#### a. Time of application

The greater part of the grassroots is found in the upper ten centimeter of soil. So, if the nitrogen can be brought into the deeper layers timely, the competition of the grassroots for nitrogen would be reduced or eliminated.

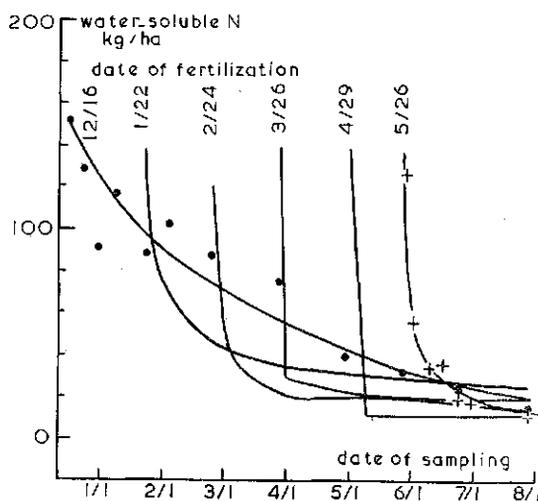
A sufficient amount of nitrogen can be transported into the zone with the densest root growth of the apple tree (20-50 cm) only if a rather large amount of rainwater is transported through the profile and low temperatures hamper the activity of the grassroots (see fig. 1), (VAN DER BOON and KOLENBRANDER, 1960).

According to data of some experiments approximately 160 mm of winter rainfall surplus will be needed on loamy clay soils to bring the zone with the highest concentration to a depth of 40 cm below the surface. On sandy soils however 90 mm will suffice for this purpose.

Two fertilizer experiments (exp. C) on clay soil showed clearly the influence of winter rainfall. The trees reacted favourably in respect of leaf colour, nitrogen content of the leaves and yield to a dressing in December, in comparison with a dressing in February during the dormant season 1959-1960. The precipitation surplus was lower than average. Leaf colour, nitrogen content of the leaves and yield were lower, however, after a dressing in November 1960 in comparison with a dressing in February 1961, due to the abnormal high precipitation in the winter months (see table 4). Production and uptake of nitrogen by the grass were higher as the nitrogen was applied later.

TABLE 4. — Influence of time of nitrogen fertilization on tree and grass

<i>Golden Delicious</i>	Time of dressing		
	November	December	February
Leaf colour markings 1960		7,1	6,7
Leaf colour markings 1961	6,9	7,1	7,3
N % leaf 1960		2,21	2,13
N % leaf 1961	2,24	2,30	2,40
Yield kg/tree 1960		10,7	8,8
Yield kg/tree 1961	20,6	23,6	23,1
<hr/>			
1st clipping grass fresh weight kg/m <sup>2</sup>	0,63	0,83	1,03
Nitrogen in first clipping kg N pro ha	34	46	62
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Rainfall mm pro month			average
	1959/1960	1960/1961	1931/1961
November	59	133	71
December	28	93	61
January	42	102	64
February	61	69	49
March	96	37	42



points, referring only to dressing on  
 ● 16 December, 1958  
 + 26 May, 1959

FIG. 1. — Six dates of nitrogen dressing in an orchard with grass. Nitrogen, found in the layer of 0-80 cm by periodic sampling. Early dressing only give sufficient nitrogen in the profile during long periods of time

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### b. Application by injection or in bands

A second method to reduce the nitrogen competition of the grass sward could be the application of nitrogen by injection.

After injecting a solution of ammonium nitrate into the soil (exp. D) or by application of bands of nitrogen (exp. E) the concentration of water soluble nitrate in the soil remained locally higher during the greater part of the growing season in comparison with the concentration of broadcasted nitrogen. The uptake of nitrogen by the grass was lower with the local application methods. The amount of nitrogen in the first cutting was 39 kg and 56 kg for the injection and the broadcast method respectively and in the other experiment 29 kg for the band method against 89 kg pro ha for the broadcast application. In spite of the fact that the aim, a less severe nitrogen competition of the grass, was achieved the broadcasted nitrogen gave a better tree reaction. Probably the tree roots could not reach the locally concentrated fertilizer sufficiently. The lateral movement of nitrogen from injected points or bands proved to be not more than 20-30 cm. These observations agree with data given by LECRENIER (1952). The yields with broadcast dressing, injection and without nitrogen were 23,4 ; 21,6 and 9,3 kg pro tree respectively. Negative results are reported by other authors also (BOS, 1961 ; GOUNY, 1950 ; LECRENIER, 1952 ; TOLHURST, 1949).

### c. Sprinkler irrigation

Water was applied in the soil management experiment (exp. A) by overhead sprinkling up to the end of July. Later application was not possible due to a content of 3 p.p.m. Fe in the irrigation water from a deep well, which caused damage to the fruit quality with later applications. Figure 2 gives some data on the soil moisture content in the upper meter of the profile during the driest year of the experiment (1959), both for a clean-cultivated and a grass plot. Under grass most of the available water had already disappeared at the end of May, whereas the soil under clean cultivation was relatively moist at that time.

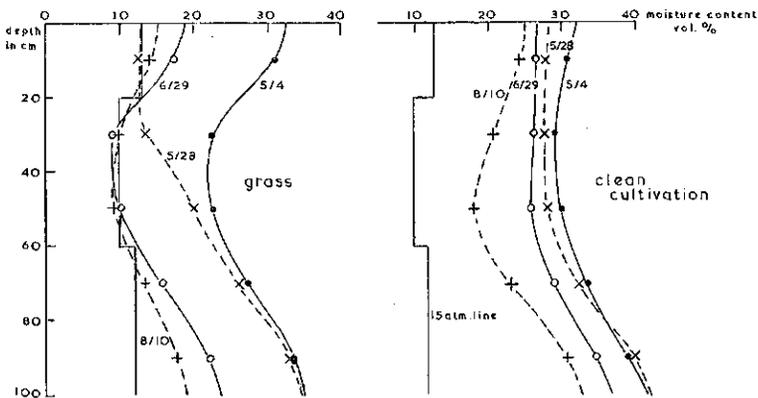


FIG. 2. — Soil moisture content in the grass and clean cultivated plots without irrigation (●—● 5/4 × ... × 5/28, ○—○ 6/29, + ... + 8/10). During the period 5/4 — 8/10 the groundwater level was lowered from 1.40 m to 2.25 m, the roots of the tree could reach a depth of 1.60 m

Irrigation resulted in a somewhat higher nitrogen level of the apple leaves. A much higher potassium and a lower magnesium content of the leaves was observed under irrigation.

Irrigation gave no increase of yield on clean cultivation, and 11 % on grass, as an average of seven years. However two years only showed a rainfall deficit during the period of shoot growth above 70 mm, whereas in most years a groundwater table of 100-150 cm enabled a contribution of capillary rising water. A significant water-nitrogen interaction did not occur, probably because the nitrogen nutrition of the trees was almost sufficient.

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#### DISCUSSION

- Q. — ROACH (United Kingdom) : Has the speaker noted any differences in the effect on the trees of different types of grasses ?
- R. — In our experiment A we have had only one mixture of grass types, mainly containing *Poa trivialis* and *Poa pratensis*.