or availability. In reply Mr. Oostendorp said that he did not think so as the calves had been leniently rotated and had had plenty of grass. He then asked for opinions on the methods of giving P.T.Z.

Mr. Loosmore explained that the daily dose method (in the food) limits egg production of the parasites and suggested that this was an easier and better method if the animals were going fat, but if the animals were for breeding replacements then periodic dosing gave the animal some chance of building up immunity.

Dr. Lambourne observed that Southcott in Australia had obtained good results in feeding P.T.Z. to sheep in a salt lick and argued that P.T.Z. prevented reinfection by inhibiting the development of larvae from the eggs. Dr. Davies asked if P.T.Z. killed off the worms or limited egg production.

Mr. Loosmore said that this was the difference between the methods i.e. that daily small doses inhibited egg production while periodic dosing kills off the adults.

THE INFLUENCE OF LEYS AND GREEN MANURE ON THE AVAILABILITY OF NITROGEN IN THE SOIL

J. A. Grootenhuis and G. W. Harmsen

Introduction

Though the effect of leys and different green manure crops on the nitrogen nutrition of the arable crops grown during the following years has already been studied extensively by many investigators in different countries, it is still one of the main subjects for research at our Institute. The importance of this problem is obvious, since the economy of nitrogen fertilisation and the estimation of the optimum rate of nitrogen application for the different crops are significantly influenced by it.

The time allotted to this paper does not allow us to go into detail; only the main lines of investigation will be given. During the discussion there should be ample opportunity to provide any additional information.

Most of the trials on this subject have been carried out on the experimental farm of our Institute - the H.J. Lovink farm in the north eastern polder of the reclaimed Zuiderzee. The soil in this polder is a rather heavy silt with about ten per cent. carbonates; this represents a 'young', not yet entirely consolidated, soil. However, as the results obtained on that farm correspond well with those from 'old' land of the same type, we shall consider them valid for the whole country.

Experiments, Results and Discussion

One of the most important trials is a long term comparison of three systems of applying organic substances as manure:

Treatment I. No addition of organic substances; only mineral fertilisers are allowed.

Treatment II. Cultivation of black medic as a green manure once in three years.

Treatment III. Ley farming with a two and a half year ley every eight years plus black medic cultivation and the application of farmyard manure.

In each treatment there is a range of nitrogen fertilising from 0 to 200 kg. N per hectare.

This experiment was started in 1953 but the first years are not included in this evaluation of the different managements. The results of this trial are shown in Figs. 1 to 6 in which the yields or nitrogen uptake are plotted against nitrogen fertiliser manuring.

In the period 1958 to 1961, the effect of the three treatments was measured by potatoes at one point in the rotation and by sugar beet at another. The

potatoes followed an arable crop on treatment I, a luxurious black medic crop on treatment II and the 2½ year ley in treatment III. The sugar beet crop followed an arable crop in treatment I and a mediocre black medic crop on both treatments II and III. In the period 1962 to 1963, the position of the potatoes and the sugar beet was exchanged in the rotation so that sugar beet followed the luxurious black medic and 2½ year ley while the potatoes followed the mediocre crop of black medic. For this reason, the yields for the first four years, 1958-1961, have been plotted separately from the second period, 1961-1963, for both the test crops.

It is evident from Fig. I that the ley in the ley farming treatment not only provided the beet with a considerable amount of nitrogen - yields were higher where no nitrogen fertiliser was given than after either of the other two treatments - but it also raised yields to levels which could not be achieved on the other treatments irrespective of the application of nitrogen fertiliser. In contrast the green manure acted only as a source of nitrogen, judged from the fact that nitrogen fertiliser was sufficient to elevate yields on treatment I (the no green manure treatment) to the levels reached in the green manure treatment. Replacing the yield of crude beet by that of sugar does not alter this treatment effect - Fig. 2. The reason why the ley farming treatment raised maximum yields is still unknown. It might be through improvement of the structure or water-holding capacity of the soil or through a more favourable course of nitrogen release from the organic matter from the ley.

The reaction of the tops (leaves and crowns) to the three management treatments - Fig. 3 - does not show this phenomenon because of the applied rates of nitrogen fertiliser remained far below optimum for them.

The spectacular effect of ley farming on the maximum yield of the sugar beet does not apply to the potato crop; in all three management treatments, the same level of maximum yield can be achieved with different rates of nitrogen manuring (Figs. 4 and 5 representing the yields of tubers and starch respectively). From the data for the uptake of nitrogen, no conclusion about the effect of the leys could be drawn because the highest level of applied fertiliser was still too low to produce the maximum uptake (Fig. 6).

This experiment does not show the direct effects of a ley or a green manure crop since the cumulative influence of the fertiliser programme required by the three treatments interferes with the direct effect of one crop upon the next. The disintegration of the organic matter from a ley is slow compared with that from a leguminous crop with a result that the nitrogen effect of a ley may be less than that of clover in the first year after ploughing but may subsequently be more. In another experiment on the same farm, data were obtained on the persistance of nitrogen liberation from various green manure crops as seen in the following table.

TABLE 1. Nitrogen (inkg./ha.) taken up by spring barley and sugar-beet in the years following a ploughed under green manure.

	2 year lucerne		1 year red clover		½ year black medic*	
	Spring barley	Sugar beets	Spring barley	Sugar beets	Spring barley	Sugar beets
1953	45	85	30	65	ca.60	ca.100
1954	30	55	15	30	ca.15	ca. 25
1955	15	40	10	15	0	0
1956	10	25	red clover		black medic	
1957	5	15	20	75	ca.60	ca.100
1958	5	20	10	40	ca.15	ca. 25
1959	0	0	10	15	0	0
Sum for 6 years	110	240	115	240	ca.150	ca.250

* Derived from another trial

It is evident that the persistance of nitrogen liberation depends on the age and degree of lignification of the material ploughed in. The possible effect of the C/N ratio was not studied in this experiment but in others it was. One of these trials was carried out on the Lovink farm in 1961 when potatoes were used as a test crop; the tops, stubble and roots of the ley were analysed together. The results (Table II.) show that as the C/N ratio of the green manure increased, so the proportion of the nitrogen which became mineralised during the first year following ploughing, decreased.

TABLE II. Effect of various green manures on the uptake of nitrogen by the following potato crop

	*N in the green manure crop kg./ha.	C/N ratio	N taken up by the potatoes from the green manure kg./ha.	% of the N in the green manure available for potatoes
½ year white clover	114	11.6	110	97
½ year back medic	90	14.3	80	89
1 year red clover	78	17.7	35	45
2 year lucerne	146	19.0	50	34

* Tops, stubble and roots to a depth of 20 cm., from soil cores, 10 cm.dia.

Another field trial in 1962 on a similar soil in the older north western polder of the former Zuiderzee, the Wieringermeerpolder, scarcely confirmed these results. Again potatoes were used as the test crop and the results are shown in Table III.

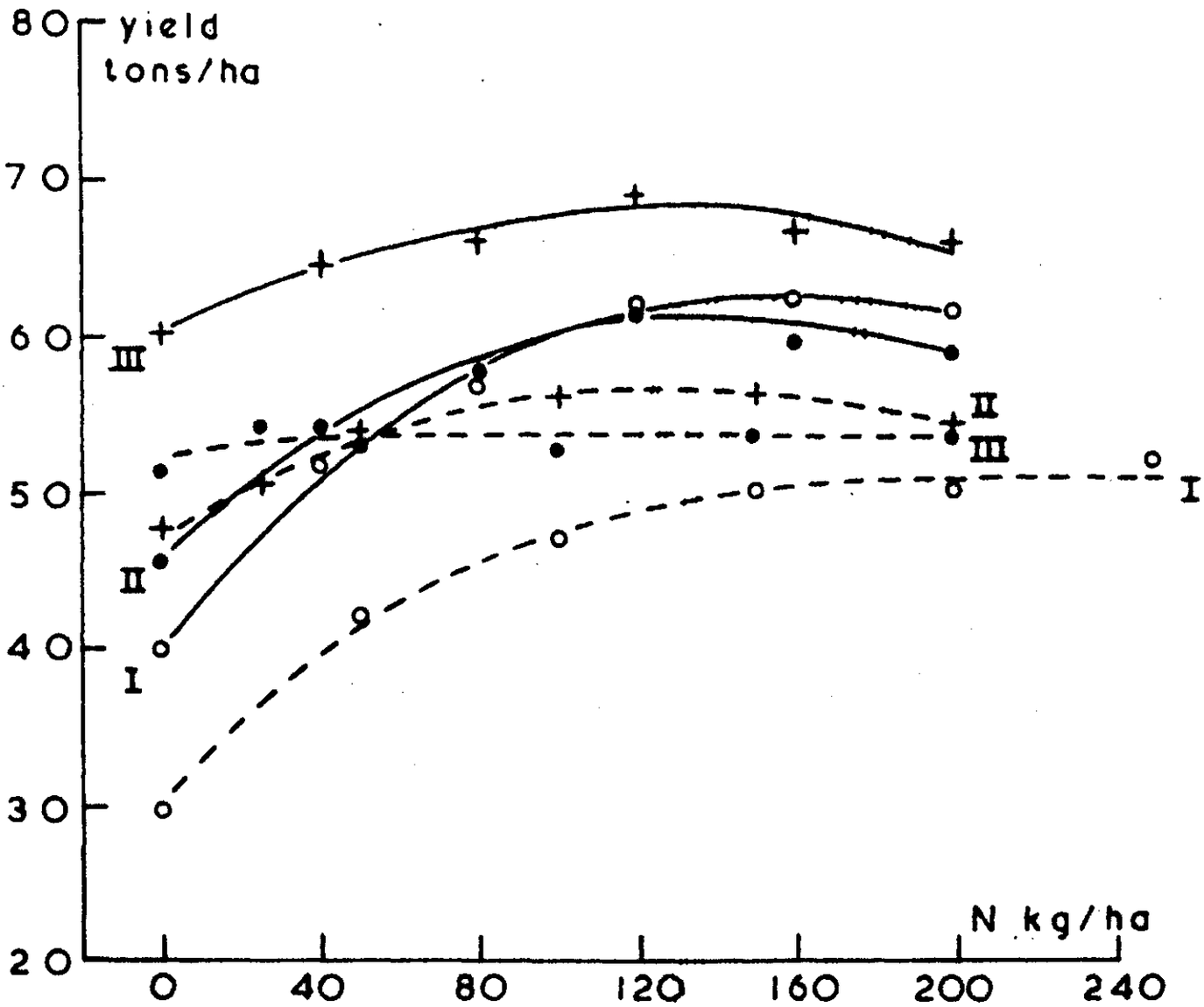
TABLE III. Effect of various green manures on the uptake of nitrogen by the following potato crop

	N in the ploughed under tops kg/ha.	C/N ratio	optimum rate of fertiliser-N kg./ha.	N apparently released by the green manure kg/ha.	% of nitrogen in the green manure available for potatoes	maximum yield of potatoes tons/ha.
No organic matter, only mineral N	-	-	180	-	-	42.2
Average from different grasses as monoculture	56	18.8	130	50	90	47.2
Egyptian clover (Berseem)	65	11.4	110	70	108	45.0
Vetches	86	9.5	90	90	105	44.4

Close agreement is apparent between the amount of nitrogen ploughed under in the tops of the green manure and the amount apparently released and taken up by the potato crop. The spectacular correlation between the C/N ratio and the release of nitrogen in the previous trial is not reproduced, presumably because no perennial crops were compared. Nevertheless, a certain, but not significant, trend towards a correlation with the C/N ratio may be deduced from these figures. The higher maximum yield of potatoes after grass than after legumes, corresponds with the results obtained with sugar beet in the first mentioned trial (Figs. I and II). It seems that grasses exert a favourable effect on the soil apart from releasing nitrogen.

In a series of field trials, the nitrogen release from ploughed leys, as affected by the percentage of clover in the sward, was studied. In these experiments the variation in clover content was mainly the result of differences in the level of nitrogen applied to the leys. Consequently, in most cases, approximately the same amount of nitrogen was released after ploughing the leys whatever their clover content. There were only two trials in which the plots with a higher

Fig. 1 Sugarbeets, roats



I Only fertilizers
II Green manure
III Ley farming
} 1958 - 1961

I Only fertilizers
II Green manure
III Ley - farming
} 1962 - 1963

Fig. 2 Sugar

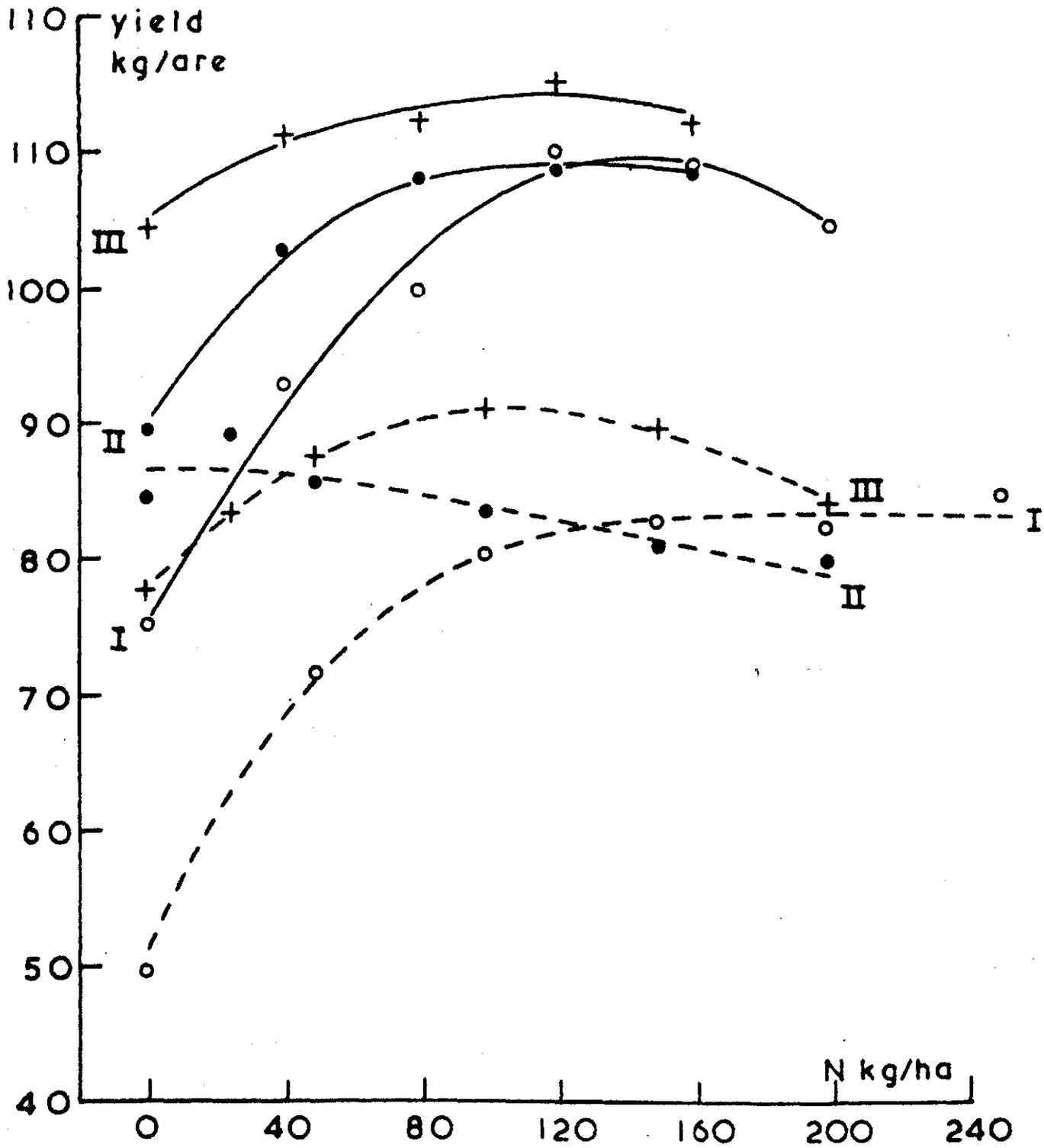
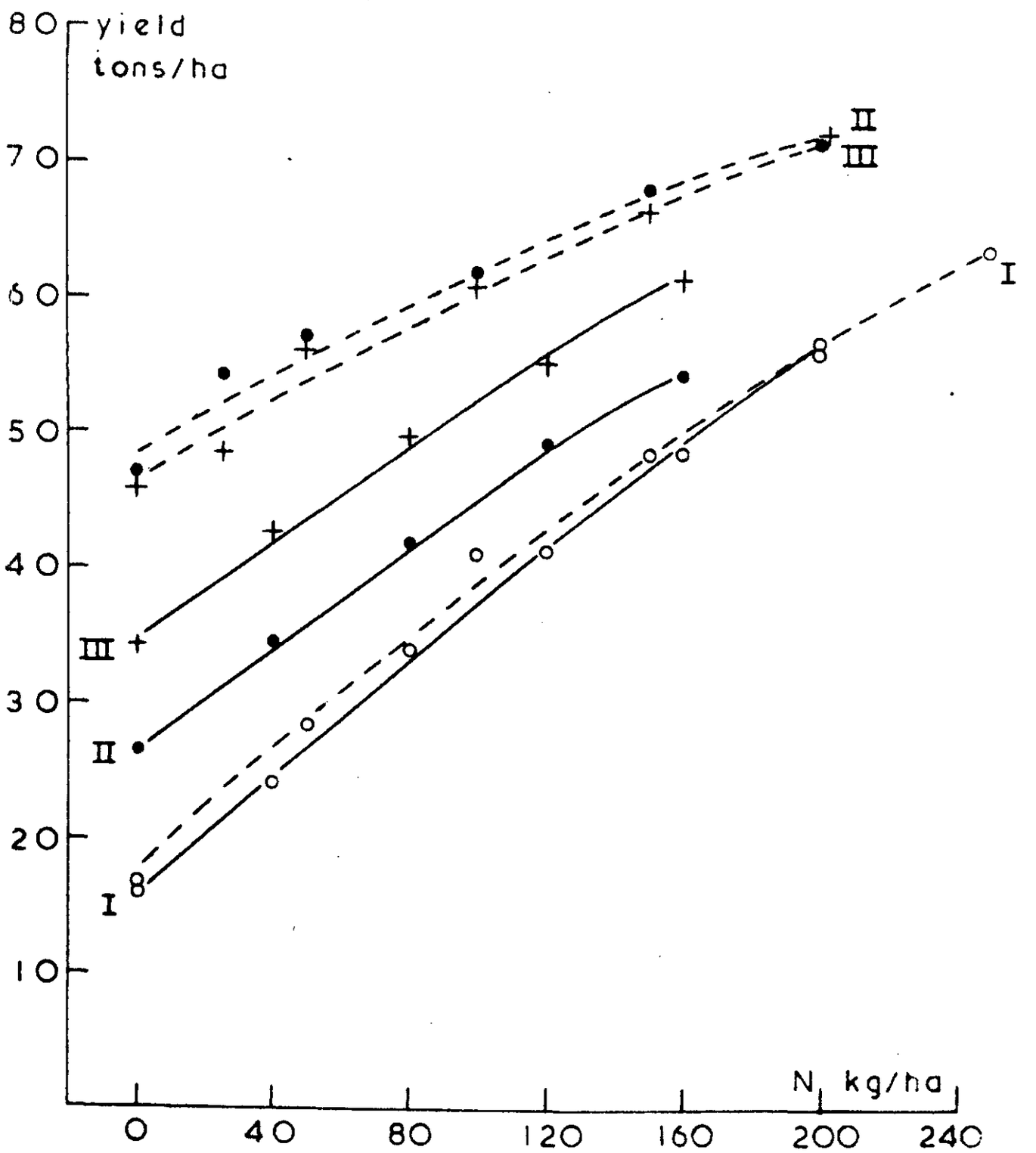

yield
kg/are
110
110
100
90
80
70
60
50
40
III
II
I
III
II
I
N kg/ha
0
40
80
120
160
200
240

Fig. 3 Sugarbeets, tops + crowns



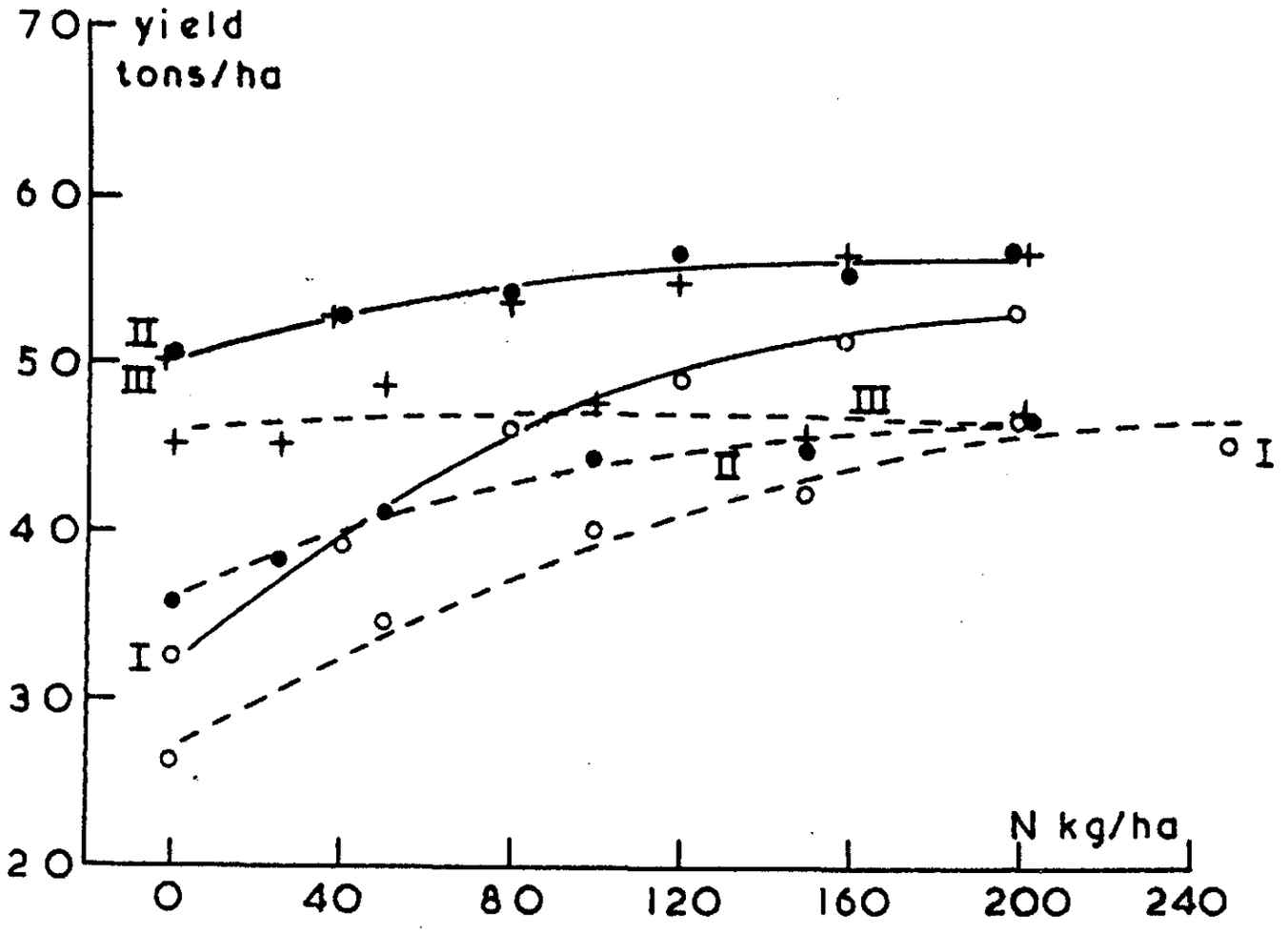

70
yield
tons/ha
60
50
40
30
20
II
III
III
II
I
I
N kg/ha
0
40
80
120
160
200
240

Fig. 5 Starch

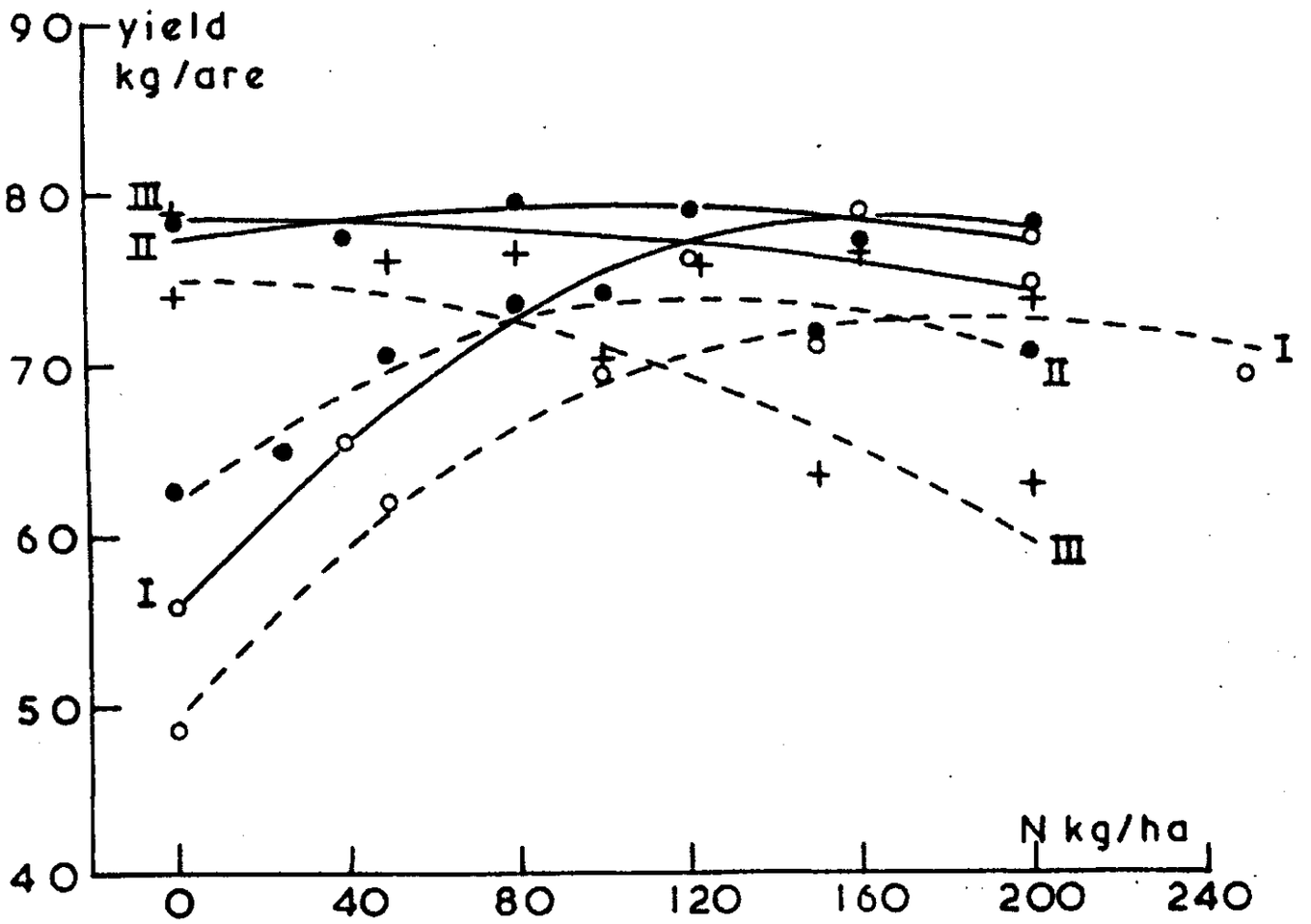
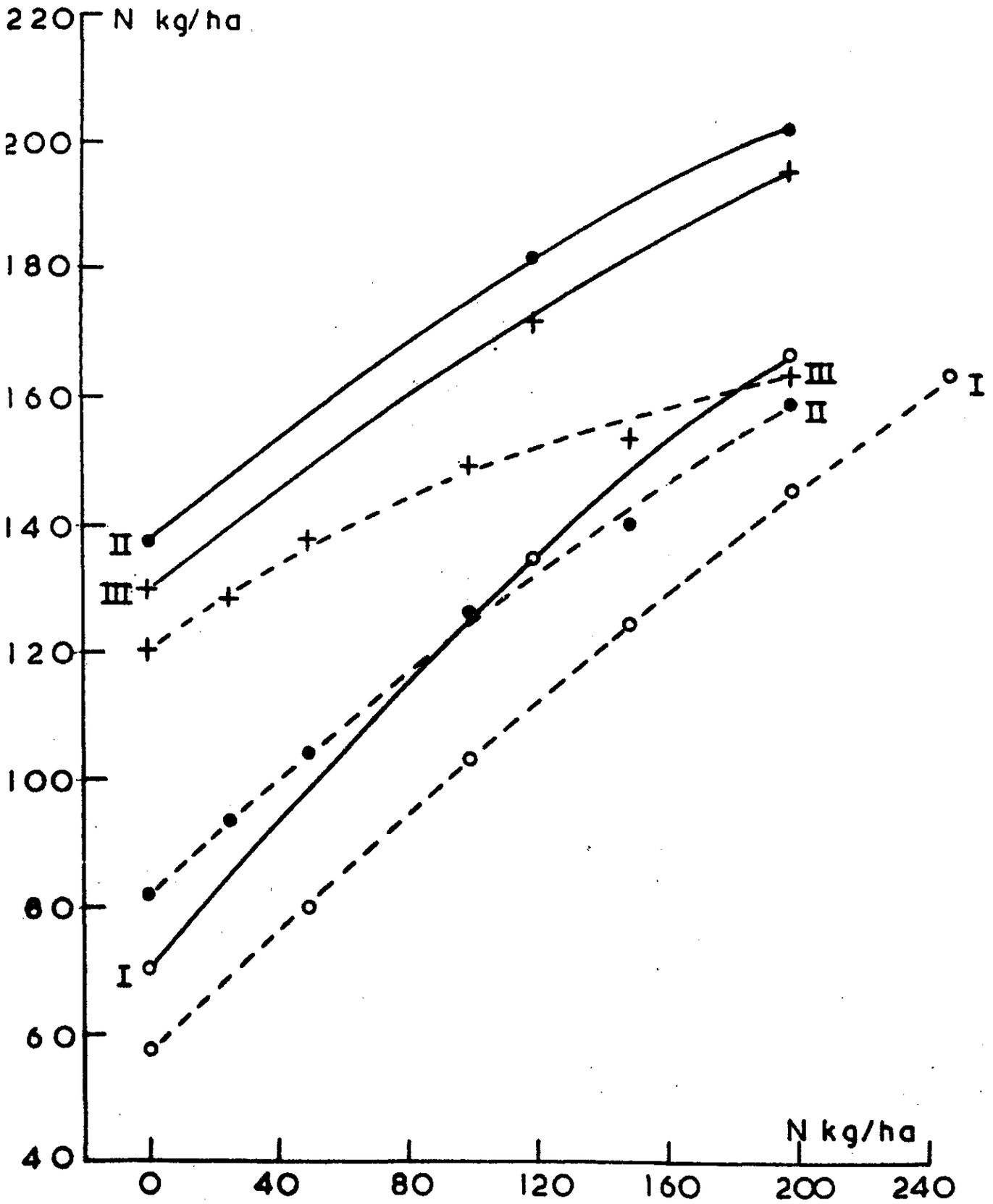

90
yield
kg/are
80
70
60
50
40
III
II
I
II
III
I
N kg/ha
0
40
80
120
160
200
240

Fig. 6 Uptake of N in potato tubers



percentage of clover (T. repens) provided the first following crop with more nitrogen than the plots with scarcely any clover. Apart from calculating the nitrogen released by means of the yield and the analysis of the crop at the optimum level of nitrogenous fertilisation, the mineralisation of nitrogen could also be followed by the analyses of the soil during the growth period of the first crop.

In one of these experiments on a calcareous silt in the province of Friesland, the top soil of plots with about thirty per cent. clover in the ley proved, in May, to contain 20 p.p.m. of mineral nitrogen more than the plots of pure grass; this is equivalent to about 50 kg. nitrogen per hectare. This difference persisted for a short period only and had disappeared by August.

The other instance in which there was a positive effect of clover on the release of nitrogen, though less spectacular, has been studied in greater detail. The characterisation of the ley just before ploughing (sampled and analysed in the same way as in the experiment detailed in Table II) is given in Table IV.

TABLE IV. Yield and analytical data from two swards of differing clover content

	yield of dry matter tons/ha.	nitrogen content of the yield %	carbon content of the yield %	C/N-ratio of tops + roots	nitrogen in tops and roots of the ley kg./ha.
ca 40% clover	10.2	1.52	41.8	27.5	155
ca 5% clover	12.1	1.70	46.1	27.0	205

Not only was the total yield of organic matter higher on the ley with scarcely any clover than on that with forty per cent. clover, but the percentage nitrogen of the organic matter was also higher as was the total yield of nitrogen. This result was achieved by the much higher rate of nitrogen fertilisation of the plots with no clover than of those with a high clover content during the period of the ley. In spite of this, the sward with a high percentage of clover disintegrated more vigorously in the spring of the following year as is shown by the data for mineralisation of nitrogen obtained by incubation of soil samples taken at different dates - Table V.

TABLE V. Data showing p.p.m. nitrogen after four weeks incubation of soil samples taken at different dates after different swards.

	9th April	15th May	24th June	31st August
ca. 40% clover	28	34	33	16
ca. 5% clover	28	28	27	18

These results demonstrate clearly that clover is less resistant to enzymatic disintegration in the soil than grass, even if the C/N ratio of the latter has been raised to the same level as that of the clover by enhanced nitrogen fertilisation. Comparing the rate of liberation of nitrogen from ploughed leys and from ploughed-under green manure, confirms this. Data from the first mentioned trial on the Lovink farm are also relevent at this point. In addition to the yields and uptake of nitrogen, as shown in Figures 1-6, the content of mineral nitrogen in the soil was also determined during the growth of the sugar beet and the potatoes. Samples for these determinations were taken three times in 1962; in the middle of May, at the beginning of July and in the middle of September, successive 10 cm. layers of the profile were sampled to one metre depth. The results are shown in Table VI.

TABLE VI. Inorganic nitrogen in the consecutive layers of the soil; p.p.m. of dry soil

Depth	Treatment I Only fertilisers			Treatment II Black medic			Treatment III Ley-farming		
cm	May	July	Sept.	May	July	Sept.	May	July	Sept.
0- 10	6	9	0	13	18	5	9	2	9
10- 20	5	5	0	12	18	4	10	13	8
20- 30	5	3	0	12	12	3	8	9	6
30- 40	5	5	0	12	10	2	9	7	2
40- 50	4	4	1	11	8	2	7	7	3
50- 60	4	5	0	8	10	2	6	7	3
60- 70	4	6	1	8	9	2	5	5	4
70- 80	4	3	2	7	6	2	3	5	3
80- 90	3	2	1	5	11	2	4	3	5
90-100	1	2	3	4	3	3	3	3	4
0-100	41	44	8	92	105	27	64	61	47

If the values for the whole profile in treatment I are subtracted from those of treatments II and III, even more contrasting data are obtained (p.p.m. nitrogen):

	May	July	Sept.
Treatment II	51	61	19
Treatment III	23	17	39

It is evident that the black medic, treatment II (it was a thick, luxuriant crop) released much more nitrogen than the ley, treatment III, in May and July but by September the situation was reversed.

One of the most important problems - perhaps the most important - concerning the value of leys and green manures, is their influence on the humus balance. The trials carried out at our Institute in the re-claimed polders of the former Zuiderzee cover too short a period to justify drawing far-reaching conclusions. Nevertheless in the principal trial under discussion, a significant difference in organic matter content has developed in the first nine years. Starting from a uniform content of 2.6 per cent. in 1953, it had changed by 1962 to 2.5% after green manure and 2.9% after the leys. Under the prevailing conditions, therefore, the use of black medic as a green manure in the rotation retards the decline in humus content but does not stop it entirely, whereas a ley of two years in a rotation of eight years significantly raises the percentage of humus. This effect, combined with an increase in the level of maximum yields of some of the arable crops and with the improvement of the structure and workability of the soil, is a powerful stimulant for the use of crop rotations incorporating short term leys. This agricultural practice is becoming more widely adopted in Holland.