

NITROGEN SUPPLY AND SOIL FACTORS

by

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INTRODUCTION

From several investigations we learned that the results of experimental fields about different amounts of nitrogen fertilizer on crop production can inform us of the influence of physical and biological factors on plant growth. So it appears that soil fertility can be described partly by the shape of the nitrogen reaction curve.

The amount of nitrogen fertilizer wanted on a certain field for maximum yield is generally observed to be quite different in different years (fig. 3). Furthermore it is known from experience that in one year there are great differences in nitrogen reaction of the crop between different fields. The point is what soil factors can account for these differences between fields in the same year. The results of the nitrogen experiments may be used to study this. Besides, we expect that the results of these experimental fields will be useful for agricultural testing of laboratory determinations on the nitrogen status of the soil.

EXPERIMENTAL FIELDS AND CHARACTERIZATION OF NITROGEN REACTION

The results of two series of experimental fields on marine clay soils are referred to. Each field was composed of a number of plots with different amounts of nitrogen fertilizer. The first series of 23 fields was laid out in 1947 with potatoes, the second of 49 fields in 1952 with sugarbeets. The amounts of nitrogen fertilizer (ammonium nitrate limestone) ranged from 0 to 137,5 kg N/ha and from 0 to 200 kg N/ha respectively; P and K dressings were optimal.

Soil structure, groundwater level, supply with organic matter etc. were quite different on the various fields and characterized by a number of determinations. Data of crop yield were gathered for each nitrogen dressing separately.

First the yields are plotted against the nitrogen dressing for each experimental field separately. The curves may be determined in a graphical or mathematical way. An example is given in fig. 1.

It appears that there are several types of reaction curves on the different experimental fields. This is shown in fig. 2 for the potato

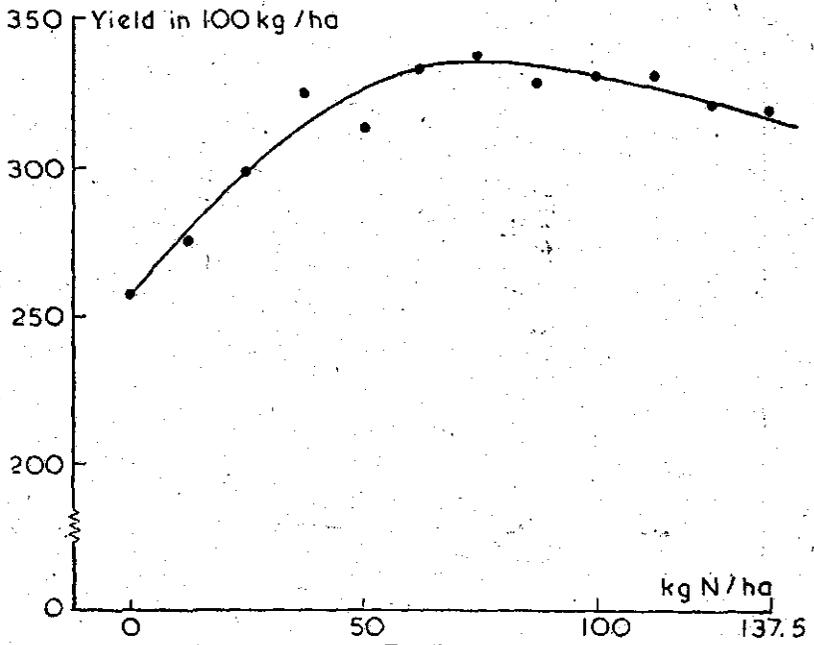


Fig. 1
Influence of nitrogen dressing on yield of potatoes on a special field.

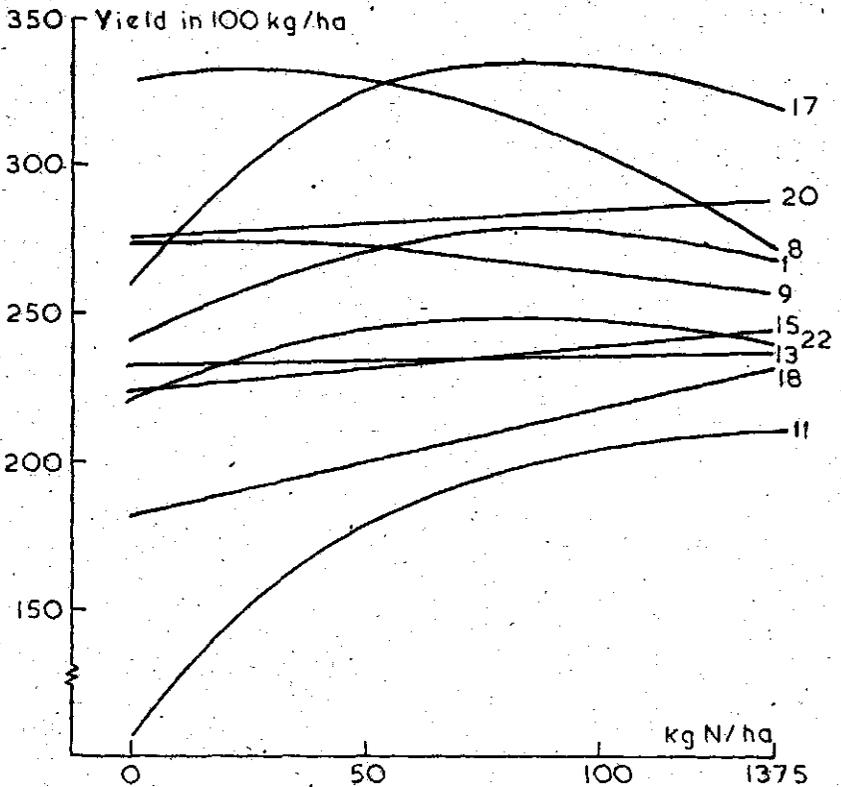


Fig. 2
Types of curves giving the influence of nitrogen dressing on yield of potatoes.

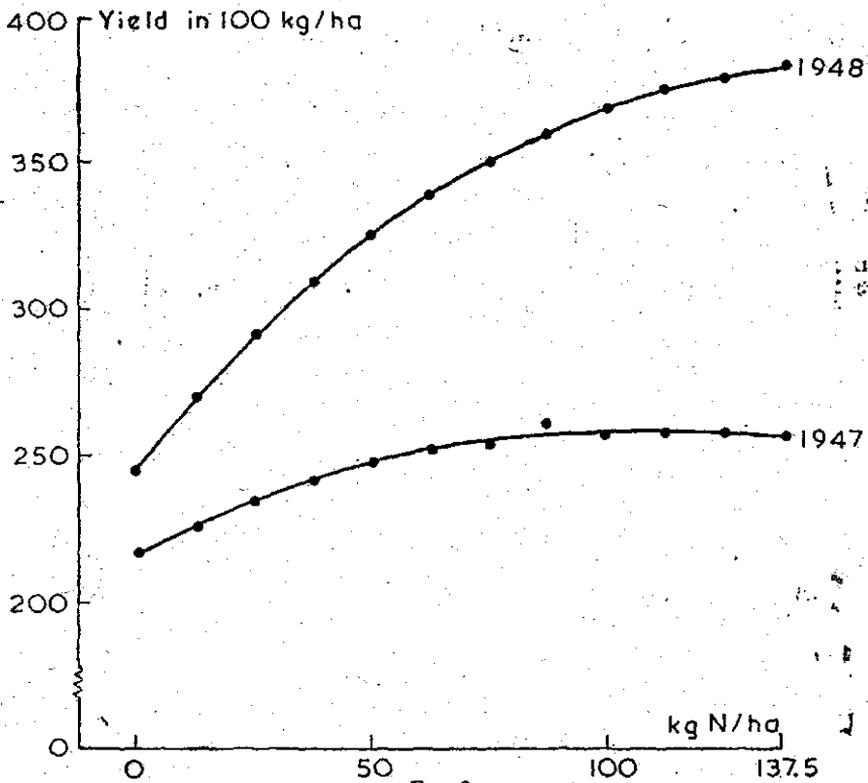


FIG. 3
Mean influence of nitrogen dressing on yield of potatoes
in the year 1947 and 1948.

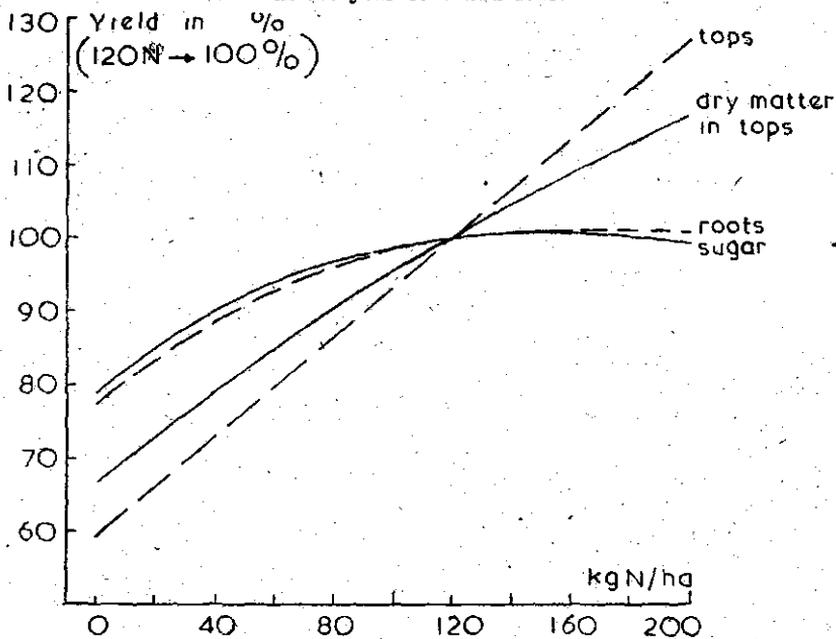


FIG. 4
Influence of nitrogen dressing on yield of roots, sugar, tops and amount of dry
matter in tops of sugarbeets.

series. Some fields react strongly and show increases in yield even at the highest nitrogen dressings. Other fields, however, show hardly any reaction or even a depression of the yield. Between these two types there are all kinds of intermediate curves. The series with sugarbeets showed about the same results but there were no curves with an optimum nitrogen dressing of zero. The fact that for this second series only fields were chosen that did not receive organic manure in the year before the experiment, neither lay in grass at any time may contribute to this phenomenon. The yield increase by nitrogen fertilizing with sugarbeets ranged from 4,2 to 23,5 tonnes/ha. Fig. 3 and 4 show the mean effect for potatoes and sugarbeets.

A great advantage in analyzing the results of experimental fields with potassium and phosphate is that we can relate the reaction of the crop to the amount of P and K in the soil as determined by laboratory methods (*Van der Pauw*, 1952). However, for the nitrogen status of the soil we still lack a suitable method of determination.

In order to explain the differences in nitrogen reaction we first characterized the curves as shown in fig. 2 by means of the following parameters:

- a) the yield without nitrogen fertilizer;
- b) the maximum yield;
- c) the amount of nitrogen given at the maximum yield.

We examined to what soil factors these parameters could be brought into relation. A great number of growth factors were taken into account. The most important are:

- 1) difference between highest and lowest yield; this factor serves as a check and is a substitute for the factor nitrogen mineralization in the soil;
- 2) visually determined soil structure (st) in spring; it is determined in the field by a specialist;
- 3) visually determined soil structure in autumn;
- 4) pH-KCl, pH measured in 1 n KCl solution;
- 5) percentage of particles < 16 microns;
- 6) groundwater level;
- 7) nitrogen mineralization in the soil (*Harmsen et al.*, 1949);
- 8) content of organic matter.

NITROGEN EFFECT AND SOIL FACTORS

The factors which would probably account for the differences between the various experimental fields obtained on plots without nitrogen fertilizer, in maximum yield and in quantity of nitrogen necessary to get maximum yield were found by means of the graphic regression analysis (*Ferrari*, 1952).

From this the following factors appeared to be important: with the potato experiment: soil structure, groundwater level and percentage of particles > 16 microns and with the sugarbeet experiment: soil structure, pH and nitrogen reaction.

The results show that the differences in yield between the different fields obtained with, respectively without nitrogen fertilizer could be

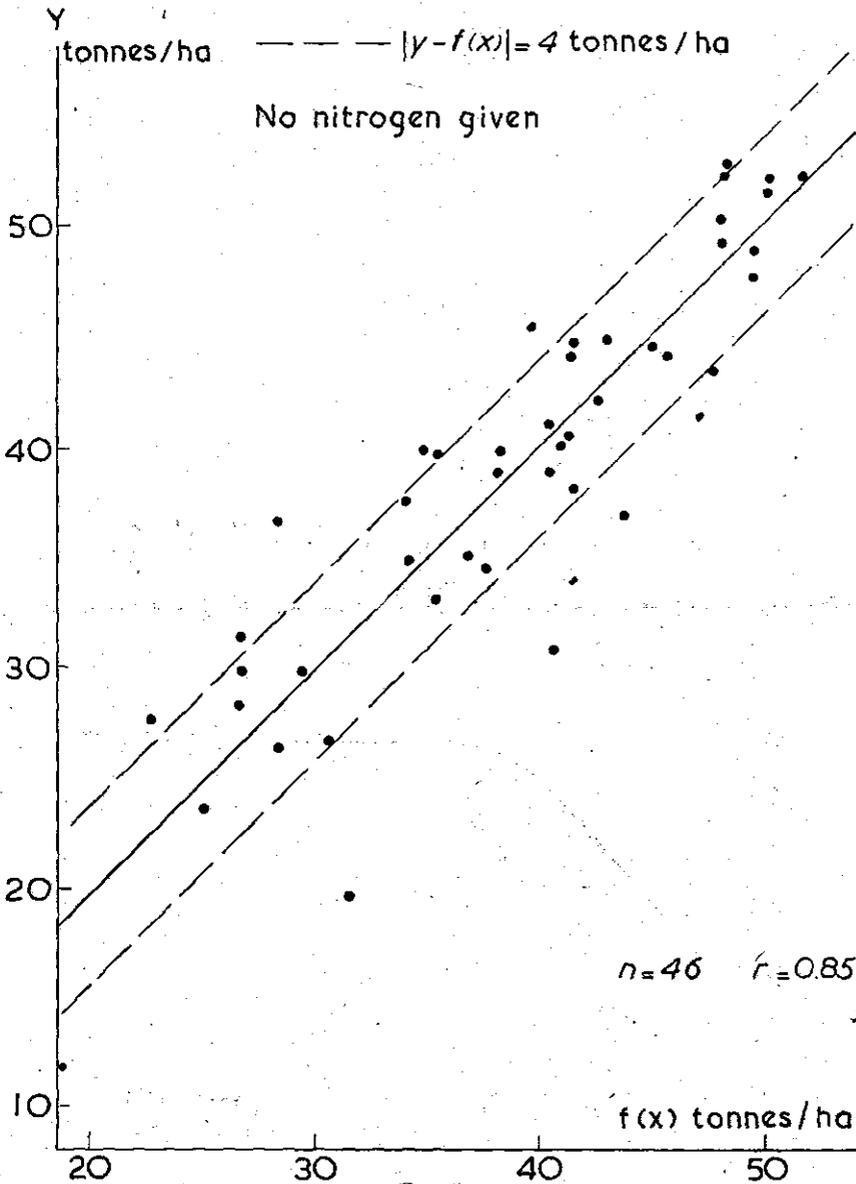


FIG. 5

Yield expected according to growth factor investigated ($f(x)$), versus yield measured in the field (y). No nitrogen supplied.

sufficiently explained by these factors as is demonstrated in fig. 5, where beet yields obtained without nitrogen are plotted against $f(x)$ i.e. the yield that would be expected according to the growth factors found. The graph illustrates the agreement of the yield figures as computed

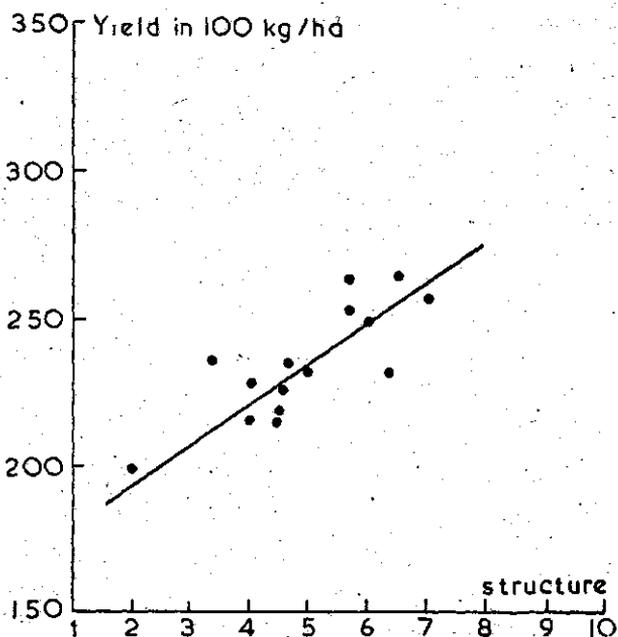


FIG. 6
Influence of soil structure on yield of potatoes, no nitrogen dressing given.

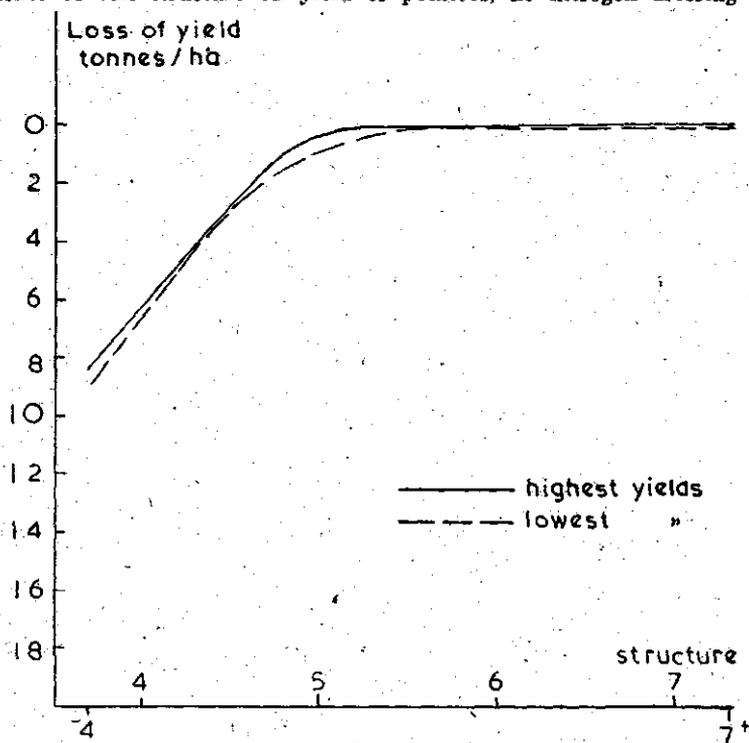


FIG. 7
Influence of soil structure on loss of sugarbeet yield.

from the growth factors with the yield figures found by measurement in the field, when no nitrogen was added.

The relation between soil structure and crop yield without nitrogen dressing is shown in figs. 6 and 7. With sugarbeets there is no increase in yield above st-figures of $5\frac{1}{2}$ in 1952 (autumn determination) but with potatoes in 1947 this figure was much higher (spring determination). At any rate the importance of a favourable soil structure is clear.

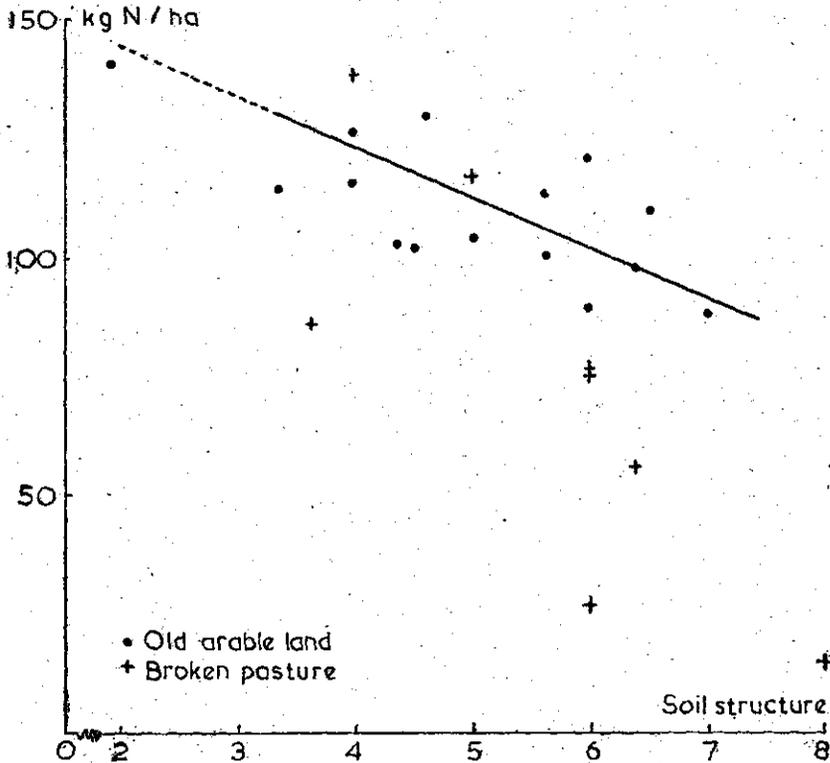


FIG. 8

Relation between soil structure and quantity of nitrogen dressing necessary to obtain maximum yield.

The influence of soil structure on the maximum yield of sugarbeets was equal to that on the lowest yields (fig. 7). As was stated above, the factor nitrogen reaction was introduced into the analysis of the yields of sugarbeets. This did not occur in the analysis of the potato yields. As the nitrogen reaction was defined as the difference between the maximum yield and the yield without nitrogen fertilizer, the relations between this nitrogen effect and these two yield data should be interrelated. No relation was found between nitrogen effect and maximum yield and from this it can be deduced that the relation between nitrogen effect and lowest yields should be a straight line with a negative slope of 45° . This proved to be correct. By introducing the N-effect as a growth factor, however, the curves for the influences

of soil structure on highest and lowest yields are expected to be parallel. This was also found to be correct (fig. 7).

The correlation between the N-effect and the nitrogen mineralization in the soil as determined in the laboratory was rather small. The correlation coefficient increased somewhat when more homogeneous soil groups were observed.

The influence of soil structure on the maximum yields of potatoes was also clear. The impression is that an increase of nitrogen dressing

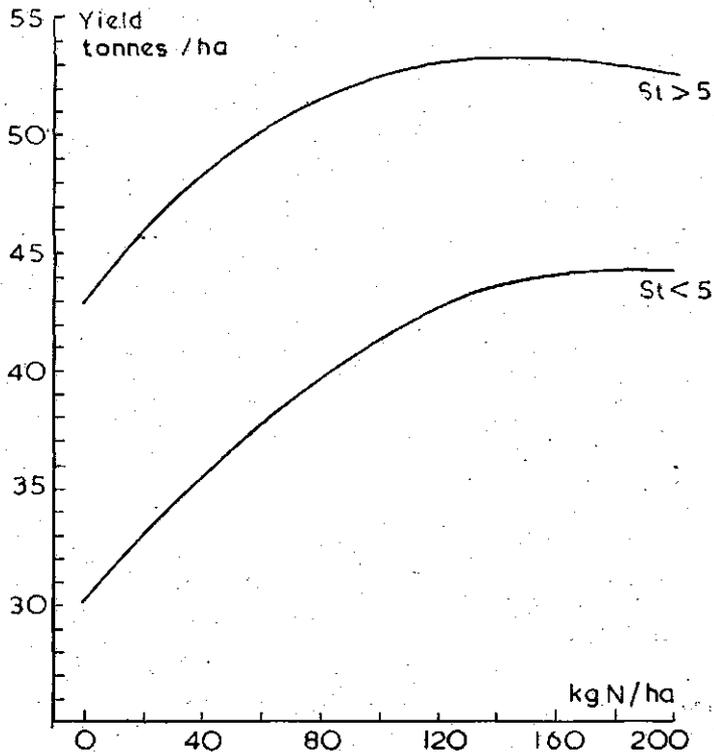


FIG. 9

Yields from fields classified in two groups according to soil structure index, in relation to nitrogen dressings.

increases the effect of bad structures. At any rate, it was clear that the influence of bad structures could not be compensated by nitrogen fertilizing.

This is not in agreement with what was found for the influence of groundwater level on the yields of potatoes. The elevation of the groundwater level proved to be of great importance for the yield of potatoes in the investigation of 1947: too low and too high levels gave a decrease of the yields without nitrogen fertilizer. At optimum nitrogen dressings these phenomena disappeared almost entirely. The effect of pH on yield of sugarbeets did not disappear, however. It is often thought that a decrease in yield caused by a too low pH of the soil may

also be eliminated by heavy nitrogen dressings. This was not found in our experiments with sugarbeets.

The amounts of nitrogen necessary to obtain maximum yields widely diverged on the various fields. For potatoes the greatest difference was about 130 to 140 kg N/ha, for sugarbeets more than 160 kg N/ha. The small requirement of nitrogen on some of the experimental fields with potatoes could be explained from the fact that these fields had been used as grassland a few years before (fig. 8). After eliminating this influence it appears that soil structure, groundwater level and percentage of particles < 16 microns sufficiently account for the differences in the requirement of nitrogen.

Fig. 8 shows the influence of soil structure on the requirement of nitrogen. The better soil structure, the lower is the amount of nitrogen required. The greatest variation is about 70 kg N/ha.

Fig. 9 demonstrates the influence of soil structure on the nitrogen requirements with sugarbeets. Nitrogen dressing is plotted against crop yield, the experimental fields being divided into two groups, one with bad, the other with better soil structures. The maximum yield is obtained at 160 and 120 kg N/ha respectively. In this experiment only a minor part of the differences in the requirement of nitrogen could be accounted for.

The reaction between soil structure, groundwater level, nitrogen effect and yield in our experiments may be summarized as follows: The influence of groundwater level can be eliminated by N-dressings; the influence of soil structure is the same for high and low N-dressings. With low N-dressings it becomes clear that bad structure goes together with poverty in nitrogen status, which can be eliminated by N-dressings, although in this case more nitrogen is wanted to get the optimum yield than with good structures.

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ZUSAMMENFASSUNG

Das Problem der Stickstofflieferung im Boden kann mit Hilfe der Reaktion der Pflanzen auf Stickstoffdüngung untersucht werden. Die

Reaktion differiert sehr auf die verschiedenen Aecker (Fig. 2). Wir haben versucht die Stickstoffkurven von zwei Serien Versuchsfelder mit Kartoffeln und Zuckerrüben zu erklären. Es war möglich, verschiedene Bodenfaktoren wie visuell bestimmte Bodenstruktur, pH, Grundwassertiefe anzuzeigen, die korreliert waren mit dem Ertrag ohne Stickstoff, mit dem Höchstertrag der mit Stickstoff erreicht werden kann, und mit der Menge von Stickstoff notwendig um diesen Höchstbetrag zu erreichen. Die Korrelation zwischen Stickstoffeffekt und den im Boden vorhandenen mineralisierbaren Stickstoff war gering.

RESUME

Le problème de l'approvisionnement en azote par le sol peut être étudié à l'aide de la réaction de la plante à une fumure azotée. Cette réaction est très différente pour les différents champs (fig. 2). Nous avons essayé d'interpréter les courbes de réaction de l'azote de deux séries de champs d'expériences avec pommes de terre et betteraves à sucre. Il s'est avéré possible d'indiquer des facteurs du sol, tels que la structure (visuellement déterminée), le pH et le niveau phréatique, qui étaient corrélatifs au rendement obtenu sans fumure azotée, ou le rendement maximum que l'on peut obtenir avec l'azote ou la quantité d'azote nécessaire pour obtenir ce rendement maximum. La corrélation entre la réaction à une fumure azotée et la quantité d'azote minérale dans le sol était minime.