PHOPHORUS LEVEL OF THE SOIL IN RELATION TO PHOSPHATIC DRESSING, NEED OF CROPS, LEACHING AND FIXATION

by

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At the Dublin meeting of Commission II and IV an exposition was given on the way in which a calibration of soil testing methods may be obtained by means of series of short-term trial-fields on which different amounts of fertilizers are applied (1). It was shown that the correlation between the results of soil tests and the reaction of the crop to the plant nutrient studied can be very close. Allowance must be made, however, for the effect of accidental factors. In this way the soil test may give very valuable indications as to the availability of a plant nutrient under farming conditions. Amounts of fertilizers needed at different nutrient levels of the soil may also be derived from the results of these experiments.

This, however, remains still incomplete for practical purposes. It is also necessary to obtain an insight into the long term effect of continous dressing on the level of the soil and into the reaction of all crops of the rotation. In addition to short-time experiments long term experimental fields are wanted. In order to obtain results of general validity and to be able to make mutual comparisons a comparatively great number of these experiments is desirable. A number of field trials with phosphate on arable land of about 10 years' duration has been distributed throughout the Netherlands during the last 15 years.

The provisional results of these experiments show that the average increase of the yields obtained with various crops by means of phosphate dressing is rather moderate:

TABLE 1

AVERAGE YIELDS OBTAINED WITH DIFFERENT PHOSPHATE DRESSINGS

	P_2O_5 (kg/ha)				
	0	30	70	120	200
clayey soil (115 yields)	95,1	97,0	98,8	99,7	100
sandy soils (81 yields)	91,9	95,0	97,6	99,4	100

The slow but continuous increase of the yields with increasingly heavy dressings is striking. The mean phosphate level of these fields was generally somewhat below the Dutch average. Thus phosphate is no dominant factor in the Netherlands.

For comparing the results of different fields the unequal needs of the crops grown must be taken into account. For this reason procentual depressions of yields caused by phosphate deficiency of different crops grown in successive years on the same trial-field have been related to

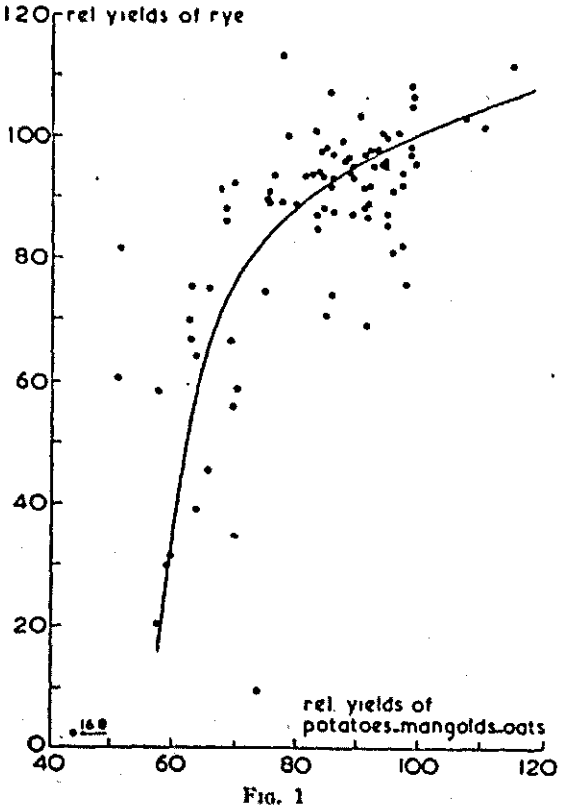

FIG. 1

Relation between relative yields (yields obtained without P dressing expressed in percents of the yield obtained with heavy P dressing) of potatoes, mangolds or oats and relative yields of rye grown in successive years. Results of various fieldtrials combined.

each other. Within certain limits the reaction of potatoes, mangolds and oats did not prove to be very different on sandy soils; in the same way no mutual differences were apparent between all grain crops and flax on clayey soils. The relation between the reaction of potatoes-mangolds-oats on the one hand, and rye on the other hand, is shown in fig. 1. Large fluctuations in the reaction to phosphate dressing occur in different years, which are responsible for the rather wide scattering of dots. Nevertheless it is obvious that the need of the first mentioned group is generally larger in case of moderate deficiency, but that the reverse is true of very deficient soils. The relation

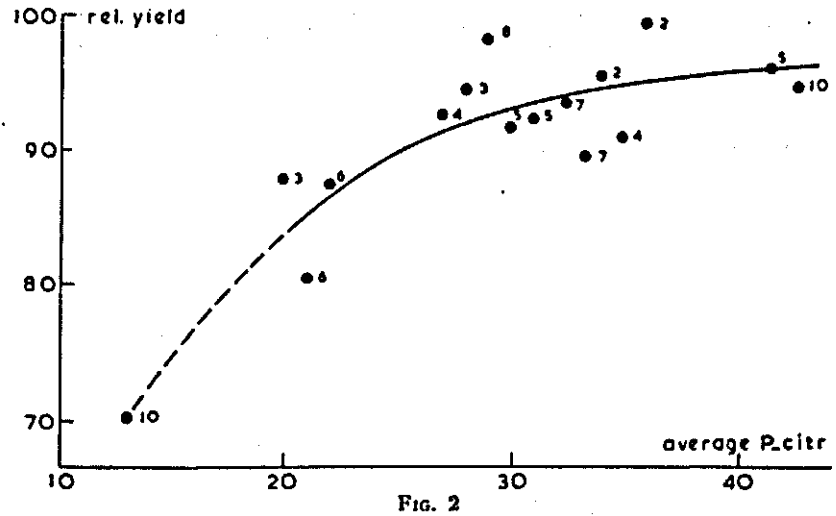

FIG. 2

Relation between P-citric acid numbers and relative yields (reduced to the reaction of potatoes—beets) obtained without phosphate dressing on claycy soils.

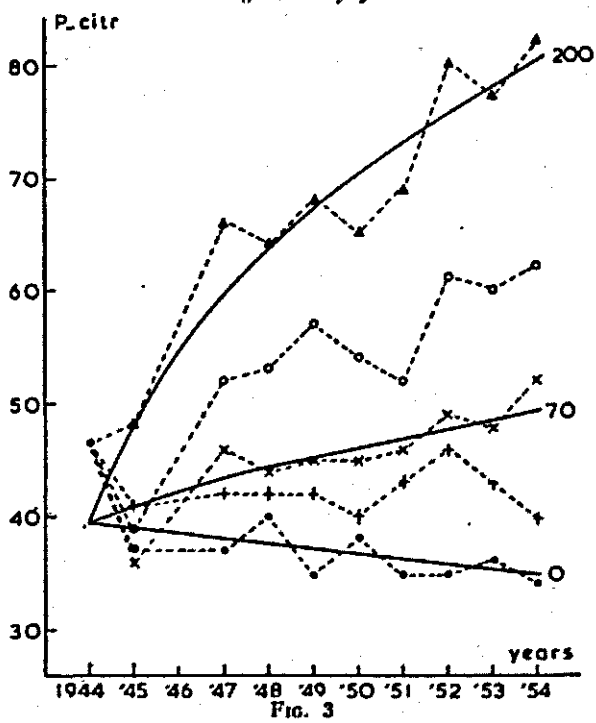

FIG. 3

Time course of P-citric acid number with different P-dressings on an experimental field and sandy soil.

expressed by the curve in this figure may be used for the reduction of the reactions found with rye to those of the other group.

The P-number of the soil (P determined in 1% citric acid) may be evaluated by means of the average results obtained with potatoes-mangolds-oats on sandy soils or potatoes-beets on the clayey soils (fig. 2). A clear correlation is found. Part of the deviations are certainly still due to the considerable yearly fluctuations of the reaction to phosphate and to errors resulting from the reduction. Phosphate-sensitive crops react considerably stronger on deficient soils than

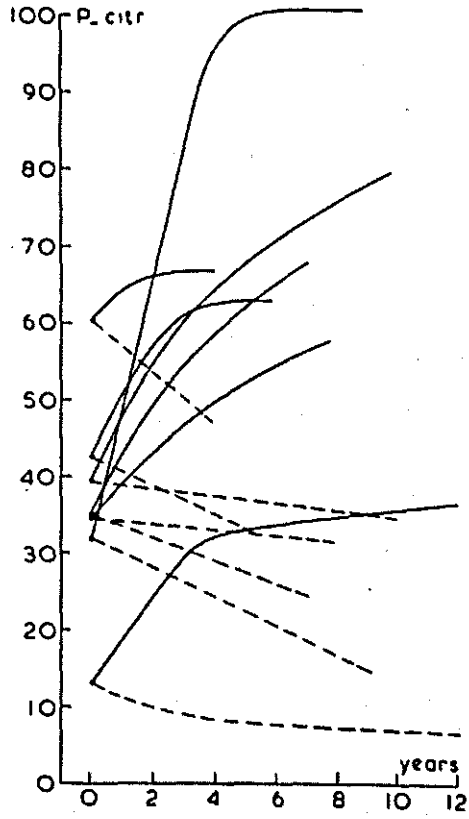

Fig. 4
Time course of P-citric number in some typical cases on sandy soil. Full lines represent yearly P dressing from 200 kg/ha P_2O_5, dotted lines no P dressing.

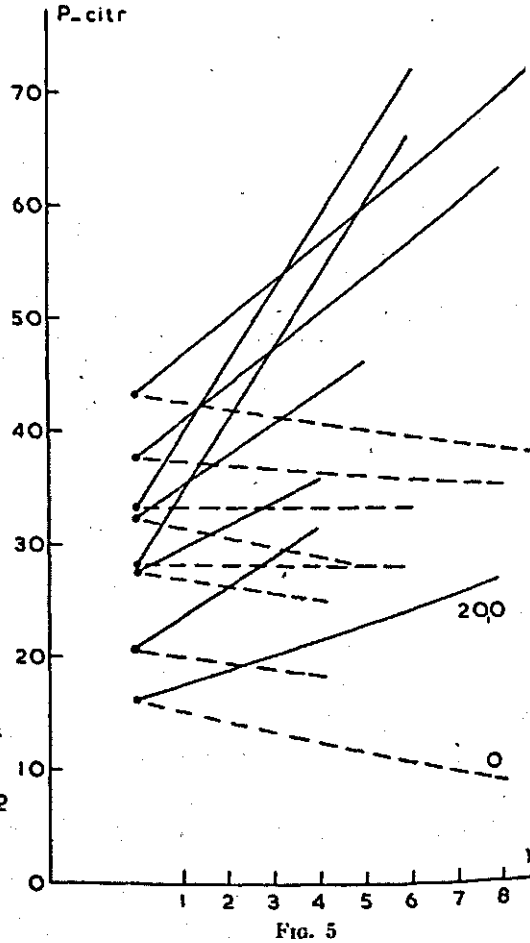

Fig. 5
Same as fig. 4 on clayey soils.

might be concluded from the mean results dealt with in table 1. It is also obvious that small increases of the yields are still possible by raising the phosphate level to rather high values.

The P-citric acid number has been determined yearly at harvest on all fields. Fig. 3 shows the results of such an experiment in a graphical form. Important differences are observed between the results of different fields, however. The time-course of P-citric in some typical cases on sandy and clayey soils is summarized in figs. 4 and 5. Only

the results of the plots without dressing and with very heavy dressing are given. On clayey soils a rectilinear increase of P-citric acid number is observed with P-dressing, on sandy soil a gradual deflexion of the curve occurs. As phosphate fixation diminishes as the phosphate status of the soil increases, it is only possible to attribute this deflexion to an increasing leaching of phosphate at high phosphate levels. Investigation of the sub-soil confirmed this conclusion. Thus leaching of phosphate on well provided soils is much more important than has been assumed till now. Building up a stock of available phosphorus,

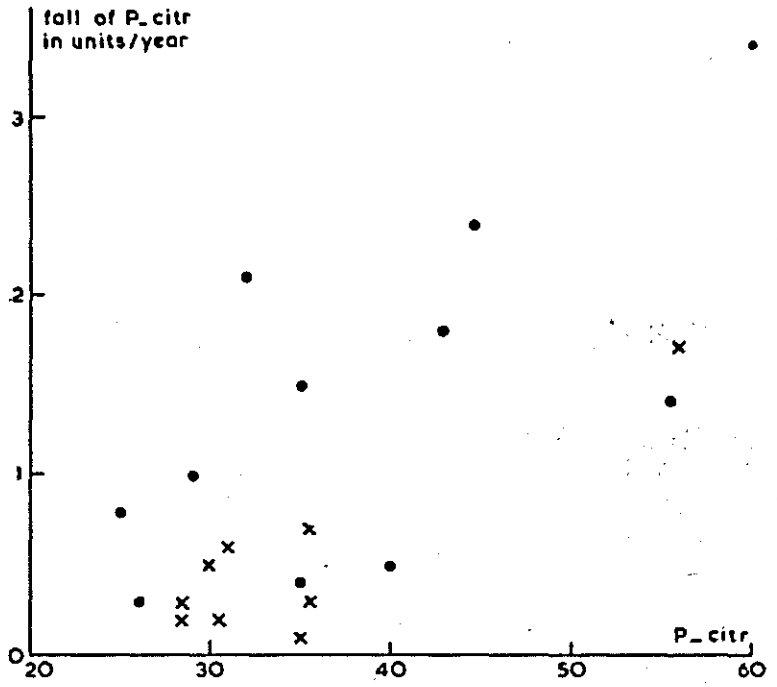

Fig. 6

Yearly fall of P-citric acid number in dependence on the height of this value.

which has always been aimed at in Dutch agriculture, may often be accompanied by considerable losses. It can also be shown that with omission of phosphate dressing the speed of the decline of the phosphate status of sandy soils is greater when the level is higher (fig. 6).

It was further found that the ratio between soil phosphate soluble in citric acid and the total amount of phosphate largely depends on the Fe_2O_3 content and the P_2O_5 content of the soil. The significance of the Fe_2O_3 content for the way in which the P-citric acid number is affected by different phosphate dressings is especially apparent on the clayey soils. The amounts of phosphate yearly dressed necessary to maintain the original P-level of the soil (determined by interpolation, see fig. 3) seem to correlate clearly with the Fe_2O_3 content (fig. 7). Only one serious deviation was found which can not be explained at present.

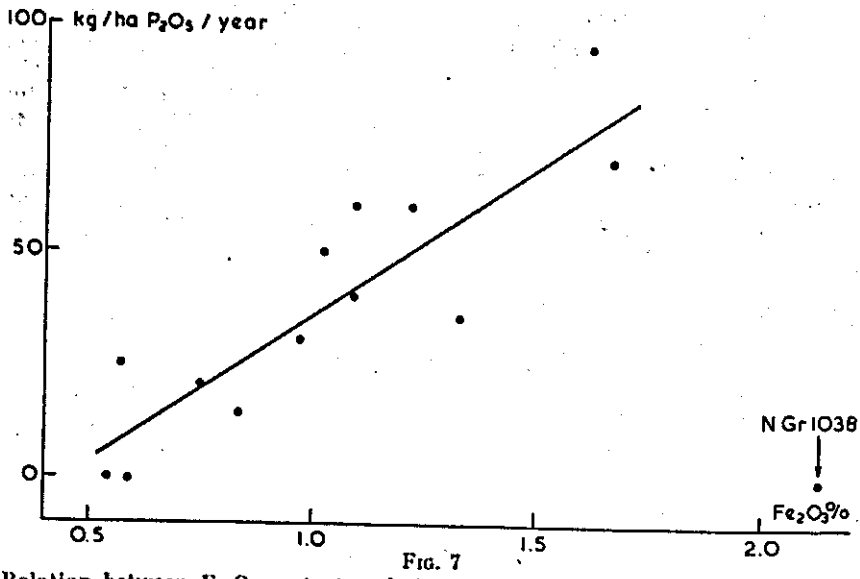

FIG. 7

Relation between Fe_2O_3 content and the amount of phosphate which must be applied yearly to maintain the original phosphate level.

The quantity of phosphate which is wanted to increase the P-citric acid number by one unit is calculable if the Fe_2O_3 content, the P-citric acid number, the volume weight (derivable from the humus content) and the thickness of the arable layer are known. To a slight extent also the pH can be taken into account.

The following results were obtained (table 2).

TABLE 2

AMOUNTS OF PHOSPHATE (kg/ha P_2O_5) NECESSARY TO RAISE THE P-CITRIC ACID NUMBER OF SOIL WITH ONE UNIT IN DEPENDENCE ON P-NUMBER AND Fe_2O_3 CONTENT FOR AN ARABLE LAYER OF 10 cm AND VOLUME WEIGHT = 1.

P-citr	Fe_2O_3%			
	0,5	2,0	5,0	12,0
10	40	70	140	210
20	30	60	100	140
30	20	50	70	90
40	15	30	45	70
50	15	30	40	70

Soil testing combined with field experimentation enables us to predict the mean reaction to phosphate dressing and to estimate the consequences of a certain fertilization pattern for the fertility level

of the soil in the long run. The effects of stock dressing as well of omission of phosphate dressing can be foreseen.

The results of the experiments described give rise to doubt as to the economy of the present practice of fertilizing in the Netherlands. It is plausible that the amounts of phosphate applied to maintain the soil status at a high level or to improve this status is not always economical.

It seems likely that a fertilizing regime based on a more rational application of the fertilizer (as is possible with the placement of fertilizers, which may double the effectiveness of the dressing), and a better adaptation to the needs of different crops at a gradually declining average phosphate level of the soils will allow a more economical use of the phosphate.

LITERATURE

F. van der PAAUW. Evaluation of Methods of Soil Testing by means of Field Experiments. Internat. Soc. Soil Sci. Joint Meet. Comm. II and IV. Dublin, July 1952. Transactions Vol. I, 207-221.

ZUSAMMENFASSUNG

Mittels mehrjährigen Versuchen kennen wir die Phosphatmengen, welche jährlich angewandt werden müssen, um schliesslich optimale Erträge zu erhalten und welche im Stande sind, den Phosphatzustand aufrecht zu erhalten oder zu erhöhen.

Die Ertragsunterschiede, welche bei verschiedener Phosphatdüngung in den Niederlanden erhalten werden, sind nicht sehr beträchtlich (Tabelle 1). Bei höheren Phosphatzuständen ist die Auswaschung bei Sandböden nicht zu vernachlässigen (Fig. 4). Der Eisengehalt des Bodens bestimmt wahrscheinlich die für Tonböden benötigten Mengen. Wenn dieser Gehalt und die P-Zitronensäurezahl bekannt sind, ist es möglich, die benötigten Mengen zu berechnen, um den P-Zustand des Bodens um einen bestimmten Betrag zu erhöhen. Die Wirtschaftlichkeit der heutigen starken Düngungen wird bezweifelt.

RESUME

Les expériences de longue durée nous apprennent les quantités d'engrais phosphatés nécessaires pour obtenir finalement les meilleures récoltes et pour maintenir ou améliorer l'économie phosphatée du sol.

Il s'est avéré que les différences de rendements sous l'influence de fumures phosphatées différentes, ne sont pas très grandes aux Pays-Bas. Le lessivage de phosphates est assez élevé lorsque la fumure est forte. Sur les sols argileux, les quantités de phosphates nécessaires sont probablement déterminées par la teneur en fer du sol.

Il est possible d'indiquer combien d'engrais phosphaté est nécessaire pour élever à un certain degré le niveau phosphaté du sol si les teneurs en fer et en phosphates solubles dans l'acide citrique (P-citr) sont connues.

Il est douteux que les fortes fumures appliquées actuellement soient économiques.