Potassium Institute Ltd.
Colloquium Proceedings No. 2. 1972.

1sn 2006139

Fertilization of Glasshouse Food Crops with Nitrogen, Phosphorus and Potassium

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Introduction

Fertilizer experiments have been carried out on tomato, lettuce and cucumber which are the most important food crops grown under glass in Western Europe. The trials, mostly of simple design, were performed in commercial glasshouses with various nutrient levels. The results of these experiments have been expressed graphically and are discussed in this paper.

Methods

When results are available from a large number of trials, the result of each is expressed in a single figure, viz. *relative yield.* Relative yield is derived by plotting yields obtained in the experiment against fertilizer rate and estimating maximum yield from a curve drawn freehand through the points. Then:

$$\text{Relative yield} = \frac{\text{Yield of control}}{\text{Optimum yield}} \times 100$$

In cases where control treatments give the highest yield:

$$\text{Relative yield} = \frac{\text{Yield of control}}{\text{Average yield of treatment plots}} \times 100$$

resulting in figures greater than 100. If only few results are available, as is the case with cucumber, yields of all treatments are included as percentage of the optimum yield.

In the first case the relation between crop response (relative yield) and nutrient status of the soil is S-shaped, in the second case the relation will resemble an optimum curve.

Cucumber was studied in only a few trials because it is a labour-consuming test crop. Besides, great quantities of organic materials, e.g. straw bales, are used in commercial growing, so it is not expected that response to fertilizers will be large. The nutrient content of straw bales is high compared with uptake by the crop as indicated in table 1 giving figures for bales of 12 and 20 kg resp. and yields of 10 and 30 kg per plant. Usually one straw bale, weighing 12-20 kg, is used for two cucumber plants. The uptake figures originate from a publication by Roorda van Eysinga and van Haeff[1], and agree with other published data[2].

Table 1—*Nutrient supply by half a straw bale, and uptake by a low and high yielding cucumber plant.*

	N	P_2O_5	K_2O	MgO
Supply (6-10 kg straw)	30-50 g	12-20 g	60-100 g	6-10 g
Uptake (yield 10-30 kg)	20-45 g	10-30 g	30-90 g	5-10 g

The straw bale can supply a great part of nutrient uptake by the crop, especially as nitrogen must be applied to the bales (at about 30 g N per plant) to induce fermentation, and sometimes phosphorus and potassium are also added (at about 15 g P_2O_5 and 30 g K_2O per plant[2]).

The Horticultural Research and Experiment Station at Naaldwijk does routine analysis of soil samples for nitrogen, phosphorus and potassium, using water as an extractant, in a ratio 1:5 (w/w), and by shaking for 15 minutes at room termperature[3]. The results are expressed as mg N, P_2O_5, and K_2O per 100 g dry soil.

Results

Nitrogen

(a) Effect on Yield

Extraction with water, or with a weak solution of an electrolyte in water, is necessary for the assessment of the nitrogen status of the soil. Determination of total nitrogen has no value as this is highly correlated with organic-matter content. Readily soluble nitrogen in glasshouse soils is mainly present as nitrate, except after steaming[4]. Water soluble nitrogen as determined at Naaldwijk includes both nitrate and ammonium.

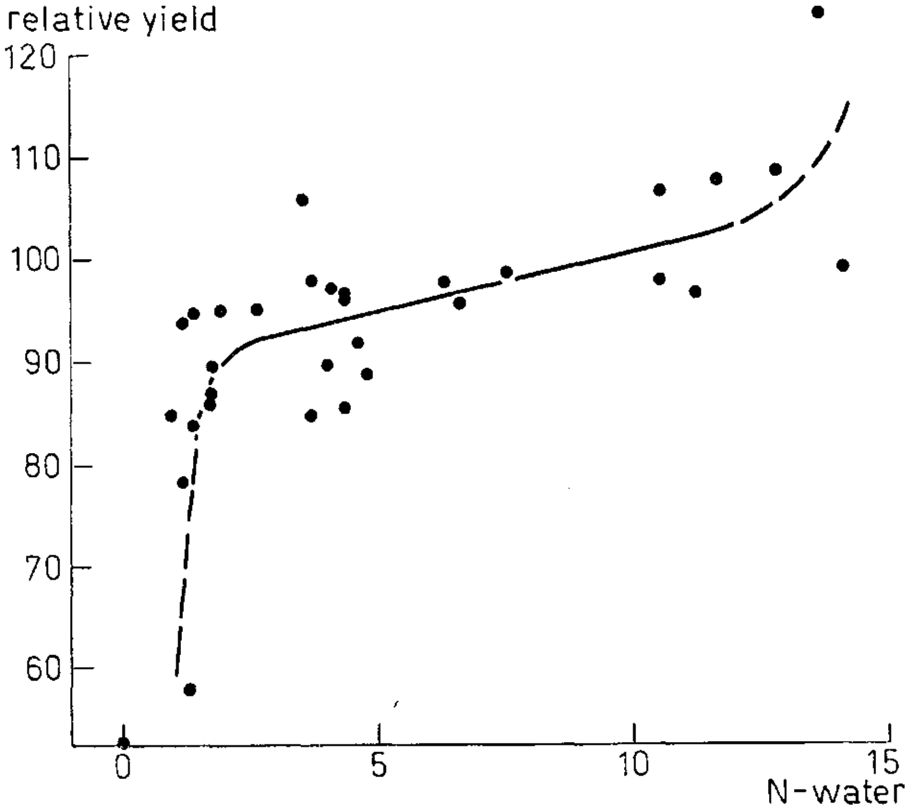

Fig. 1—Relative yield of lettuce and N-water before starting the trials.

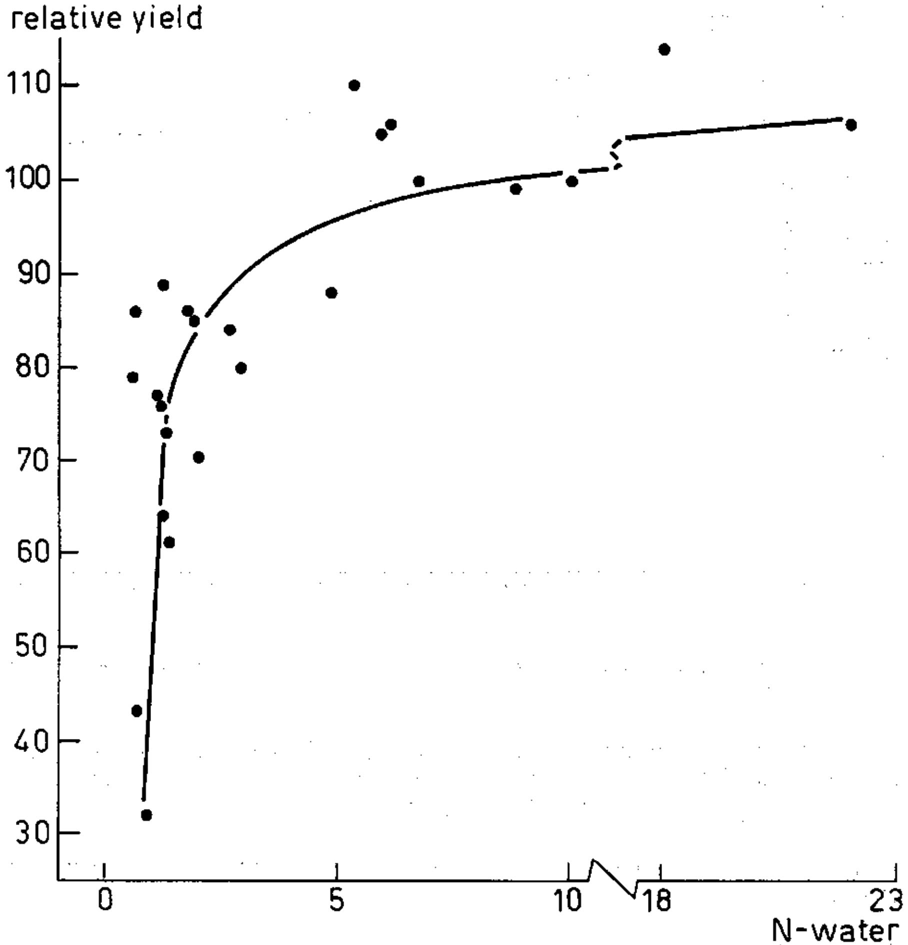

Fig. 2—Relative yield of tomato and N-water before starting the trials.

The relation between relative yield and content of water-soluble nitrogen before the experiments started is given in Fig. 1 for lettuce[5] and in Fig. 2 for tomatoes[6]. The relation between relative yields of all treatments of 6 trials with cucumbers and the average N-water content during growth is given in Fig. 3[7].

From these figures it seems that the optimum value of N-water is about 9 for lettuce, 8 for tomatoes and 10 for cucumber. Considering that these values are estimates, we may say as a result of our trials that the optimum value for the important food crops will be about N-water 10 (=100 ppm on dry soil). This value applies for the average glasshouse soil with 5 to 10% organic matter.

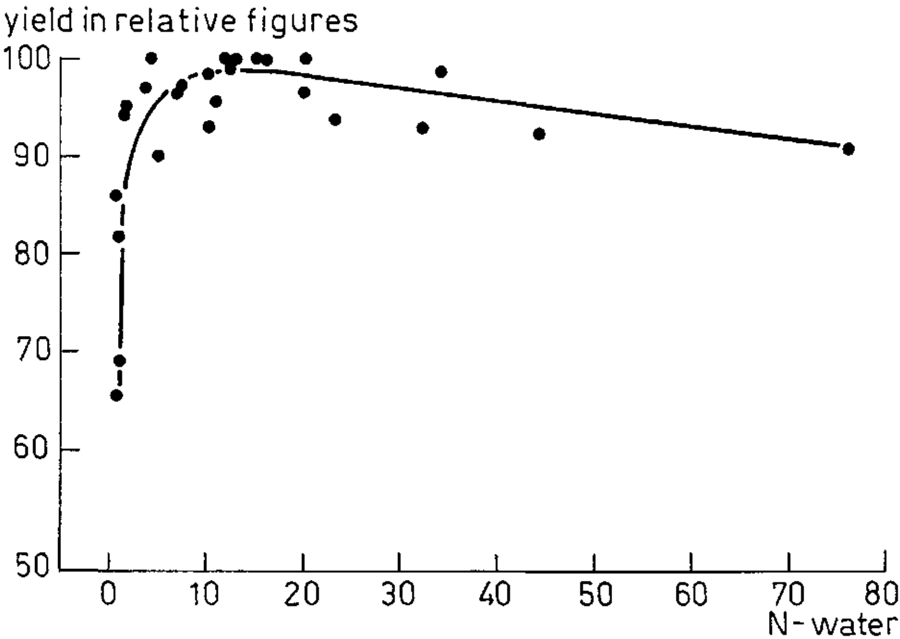

Fig. 3—Cucumber yield in relative figures (all treatments of six trials) and average N-water during cultivation.

Soils poor or rich in organic matter need lower or higher values respectively. The advisers of the Horticultural Station at Naaldwijk use the formula:—

$$\text{optimum N-water} = \frac{2 \times \%\ \text{org. matter} + 15}{3}$$

This formula is based on the high correlation between soil organic matter and moisture holding-capacity[8].

(b) Influence on Disorders

High nitrogen levels can increase tip-burn in lettuce. However, we seldom observed this influence in our trials. A constant soil-moisture content and the use of adapted lettuce varieties are thought to be important factors in controlling tip-burn.

With tomatoes increasing nitrogen decreased the incidence of *Botrytis cinerea* and also fruitfall due to this fungus. The influence of nitrogen on fruit quality was more often positive than negative, but no explanation for the varying effect could be found[6].

With cucumbers nitrogen increased the percentage of pointed fruits; low and high levels decreased fruit size[7].

Phosphorus

Many methods for the anlaysis of soil phosphate are described in the literature. For soils in the Naaldwijk area, characterised by a low to moderate

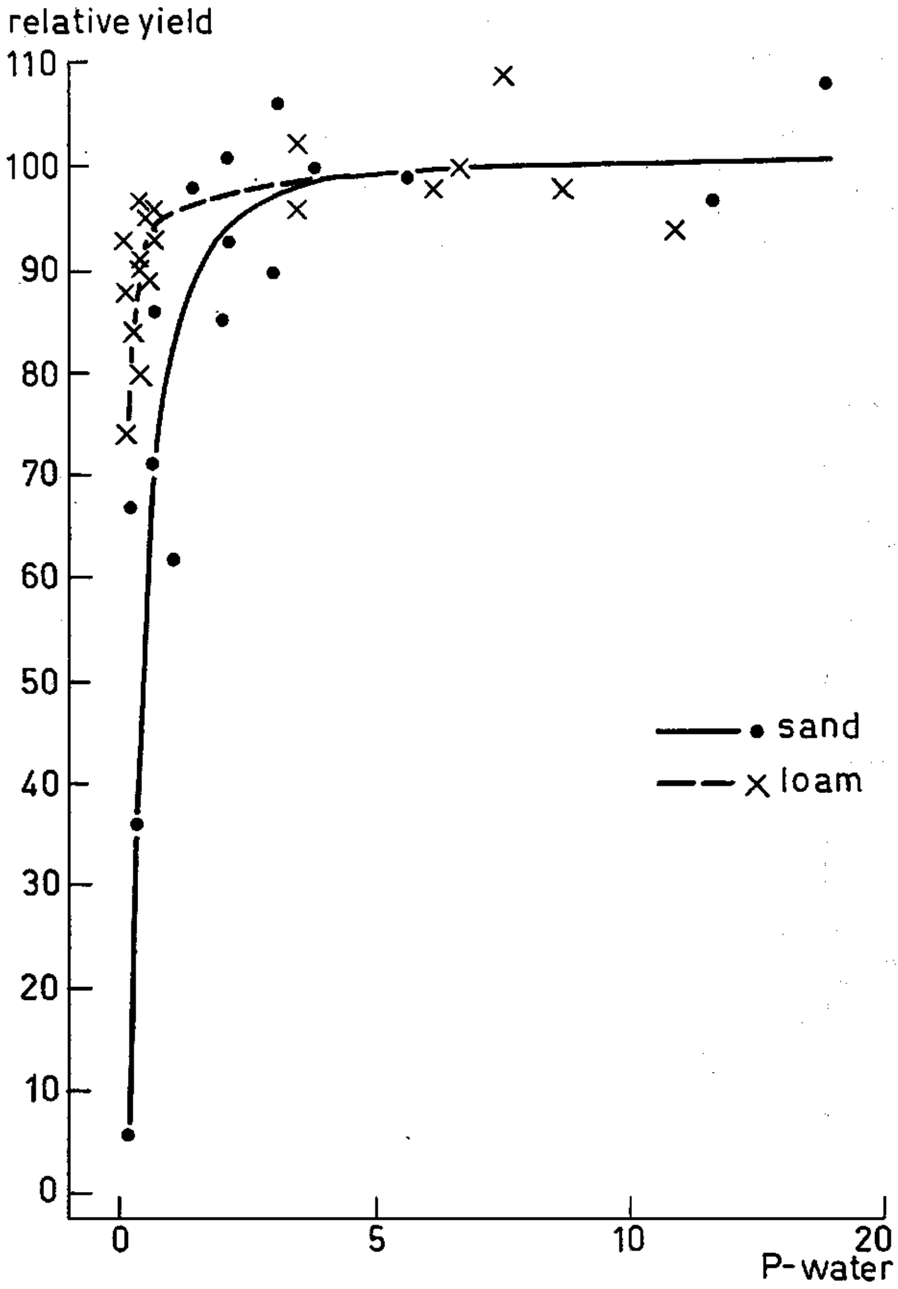

Fig. 4—Relative yield of lettuce and P-water before starting the trials.

carbonate content (0·2—5% $CaCO_3$) and a constant water table, we found high correlations between the phosphate figures according to various methods[9]. This was not true for the mainly slightly acid soils in use for glasshouse cultivation in the southeast of the Netherlands, where the water table fluctuated. In that area weakly acid solutions were superior for determining the phosphate status of soils[10].

Of the three crops discussed lettuce is most sensitive to phosphate supply. Fig. 4 shows the yield of lettuce in relation to water-soluble phosphate (P-water) determined before the trials started. Using the overall regression equa-

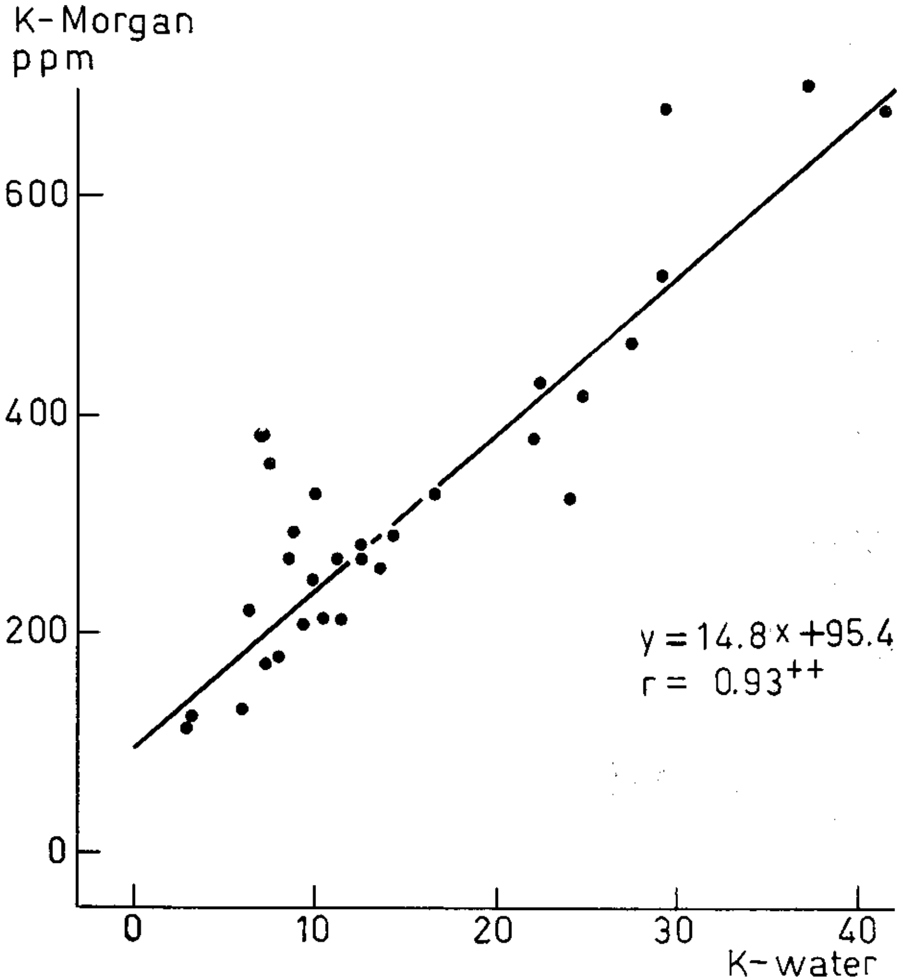

Fig. 5—Relation between soil potassium determined in an extract with water and in Morgan's solution.

tion: $y=16 \log x + 86{\cdot}6$ (see also Fig. 4), the threshold value above which phosphate should be omitted was calculated to be P-water 7[9].

For tomato the threshold value 5 was found[11]. Contrary to the findings with lettuce[12] the phosphate effect of farmyard manure was important for tomato and perhaps even more so for cucumber[7].

Phosphate had practically no influence on fruit quality of tomatoes. There was no influence on quality of lettuce, or, in the few trials, of cucumber.

Potassium

Soil potassium values determined with various extractants are closely correlated at least within one soil type. Fig. 5 shows the relation between values obtained by water extraction (Naaldwijk method) and in Morgan's extract[13] for commercial soil samples taken in January 1971, mainly from loamy sands in the Naaldwijk area. More details are given by Mostert and Van Dijk[14].

There were few trials with lettuce and cucumber. The results with lettuce are summarized in Fig. 6, the straight line drawn through dots indicating yields in relative figures from two trials in the glasshouse border soil. The broken line is abstracted from results of lettuce grown in concrete pots filled with various soil types[15]. Soil potassium was determined at the end of the trials.

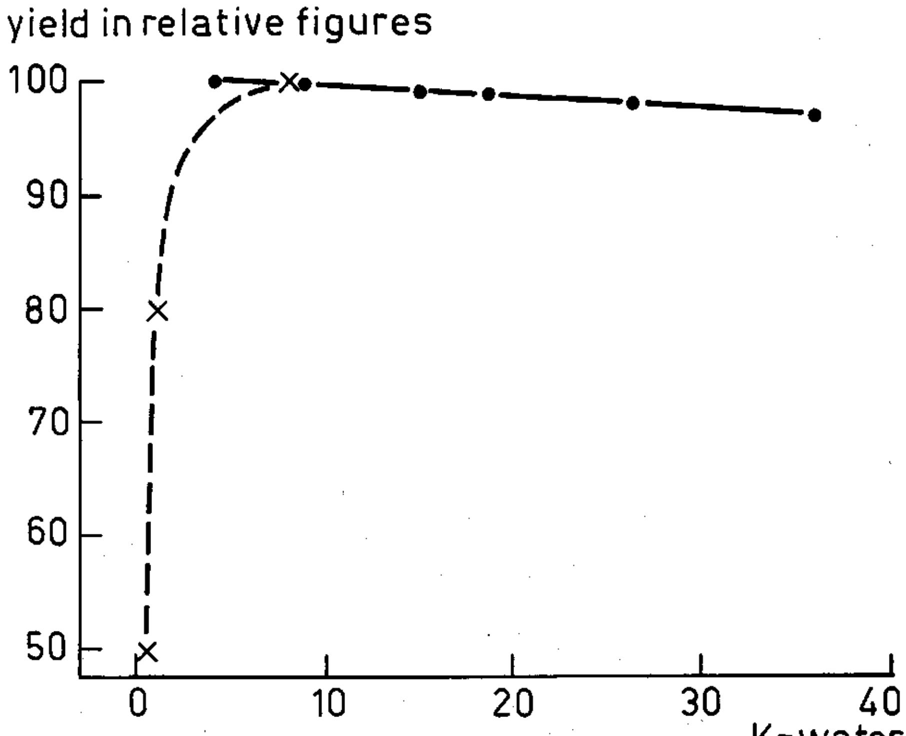

Fig. 6—Lettuce yield in relative figures (all treatmens of three trials) and K-water at the end of cultivation (x=results from an experiment in pots).

For cucumber it turned out, as for lettuce, that the omission of potassium for one season gave no clear crop response under commercial conditions. The dots in Fig. 7 represent the treatments of three trials, one in concrete pots (K-water below 15) and two in commercial glasshouses. Soil potassium is given as average figures measured during cultivation.

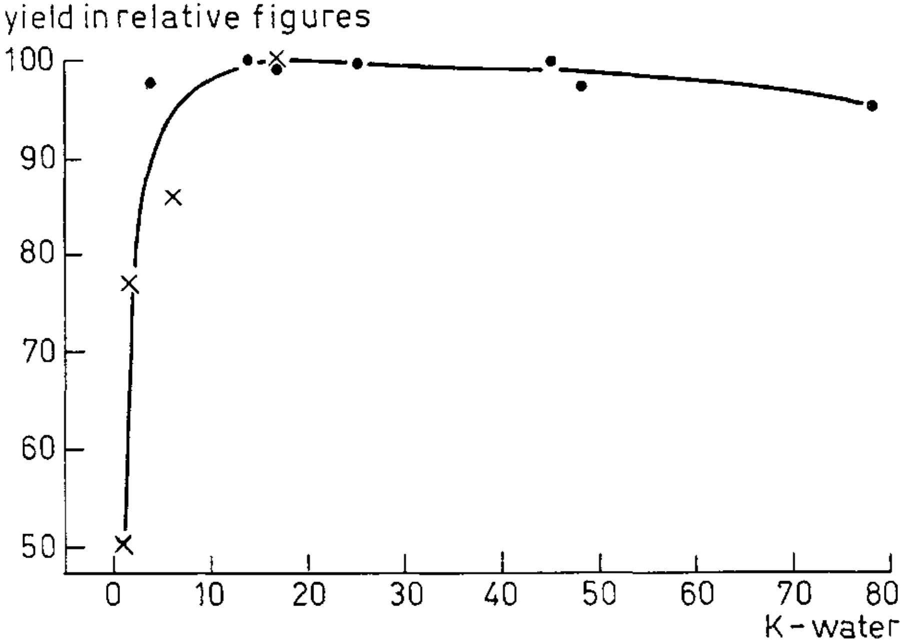

Fig. 7—Cucumber yield in relative figures (all treatments of three trials) and average K-water during cultivation (x=results from an experiment in pots).

For lettuce optimum K-water is about 6—8, for cucumber about 15, but these figures are rough estimates only.

There was no influence of potassium on lettuce quality; increasing the rate on cucumber produced more pointed fruits.

Fig. 8 gives results for tomato in terms of both total yield and yield of evenly coloured fruits only. Potassium was determined in soil samples taken before the trials started. The influence of potassium is more pronounced on yield of evenly coloured fruits (i.e. yield of "Extra" quality according to OECD-norms) than on total yield, and the threshold value for quality is higher (K-water 20—25) than for total yield (K-water 10—15). Heavier potassium dressings are needed for optimum quality than are required for highest yield[16].

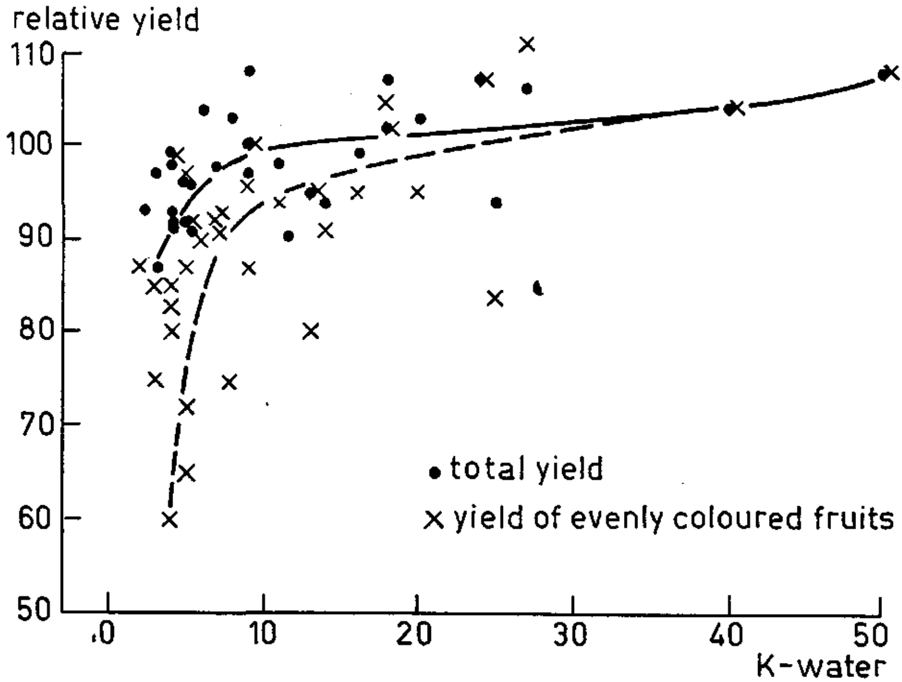

Fig. 8—Relative yield of tomato and K-water before starting the trials.

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