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# Fertilization of tomatoes with phosphate

samenvatting:

Bemesting van tomaten met fosfaat

zusammenfassung:

Düngung von Tomaten mit Phosphorsäure



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*Wageningen*

## Abstract

Roorda van Eysinga, J. P. N. L. (1971) Fertilization of tomatoes with phosphate. Agric. Res. Repts (Versl. landbouwk. Onderz.) 755, pp. (iv) + 10, tables 5, figs 5, Eng., Du. and Germ. summary.

Eleven trials with several tomato varieties in commercial glasshouses and with different soil phosphate levels are described. Each trial involved 0, 5, 10 and 20 kg triple superphosphate (43 % $P_2O_5$) per 100 $m^2$. In two trials manure was applied.

The threshold value, the phosphate content of the soil above which applied phosphate does not give a higher yield, corresponded with P-water 5.0 and P-AL 112.

In newly-built glasshouses on poor soils 20 kg triple superphosphate per 100 $m^2$ is the optimum. Where manure is applied, the optimum amount of triple superphosphate must be reduced with at least half the amount of phosphate applied with the manure.

Phosphate has practically no influence on fruit quality.

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## 1 Introduction

The influence of phosphate on production and quality of tomatoes was studied and a general advice for applying phosphate based on soil analysis, was drawn up.

In general outline the experiments were carried out as in the phosphate trials with lettuce (Roorda van Eysinga, 1971a) although on a smaller scale. This study included the effect of manure (see also Roorda van Eysinga, 1962).

## 2 Materials and methods

To study the influence of triple superphosphate (43 % $P_2O_5$) on production and quality of tomatoes in commercial glasshouses four amounts were applied: 0, 5, 10 and 20 kg per 100 $m^2$ (mostly in quadruplicate). In two trials farmyard manure or liquid manure (a mixture of solid excreta and urine) was also applied and studied (see Table 1).

From the results of soil analysis base and top dressings were added to give an optimum situation of the other nutrients. All base dressings were rotavated in, a few days before planting out. The plots were 3.20 m wide and, 4.50 or 6 m long.

Table 1. Survey of the trials.

| Trial | Location | Soil type | Plant date | Variety | Remarks |
|---|---|---|---|---|---|
| W 31 | Naaldwijk | loamy sand | 3/5/'63 | Victory | |
| FPA | Monster | dune sand | 6/1/'65 | Victory | |
| FPB | de Lier | young marine loam | 25/3/'65 | Victory | |
| FPC | Loosduinen | dune sand | 2/7/'65 | Extase [2] | FYM also studied |
| HPA | Loosduinen | dune sand | 7/12/'65 | Victory | FYM and liquid manure |
| IB 1280 | Zuidwolde | old marine loam | 10/4/'67 | Maascross [1]<br>Extase [2] | two varieties |
| vtH | Naaldwijk | sandy loam | 22/3/'68 | Victory | |
| Zw | Maasdijk | young marine loam | 20/4/'68 | Victory | |
| So | Hoek van Holland | young marine loam | 7/5/'68 | Acram [3] | |
| PNL | Venlo | old river loam | 24/4/'69 | Jupiter [1] | |
| vdE | 's-Gravenzande | loamy sand | 6/6/'69 | Azes [2] | |

1. Hybrids of the no green back type.
2. Intermediate type.
3. Hybrids of the green back type.

The outer plant rows were regarded as guard rows; the number of plants per plot varied from 14 to 20.

Before the experiments started, soil samples were taken from the 0–25 cm layer. They were analysed in the laboratory of the Glasshouse Crops Research and Experiment Station (Proefstation voor de Groenten- en Fruitteelt onder Glas) at Naaldwijk and in the Laboratory for Soil and Crop Testing (Bedrijfslaboratorium voor Grond- en Gewasonderzoek) at Oosterbeek. For important date see Table 2.

For the determination of P-water the soil was extracted with water in a ratio of 1:5 (w/w) (Dekker, P. A. den & P. A. van Dijk, 1963, Voorschriften analysemethoden. Intern Rapp. Proefstn Groent.- en Fruitteelt Glas, Naaldwijk); for P-AL an ammonium lactate, 0.04 N acetic acid buffer with pH 3.75 was used in an extraction ratio 1:20 (w/w) (Egnér et al., 1960). The phosphate content is given in mg $P_2O_5$ per 100 g dry soil for both determinations.

For crop analysis the first leaf above the third truss was taken, after this leaf fully matured. The sampling date coincided approximately with first picking. Leaf samples were collected from 10 trials.

The evenly and unevenly coloured fruits (the first belonging to the class 'Extra' according to trade standards applied by the Organization for Economic Cooperation and Development) were weighed.

To determine relative yields, the yield figures of each trial were plotted against the four amounts of applied phosphate and a curve was drawn through the dots by hand. The relative yield was calculated by expressing the yield of the O P-treatment as a percentage of the maximum yield. In one trial the O P-treatment gave the highest yield; in this case the relative yield was expressed as a percentage of the yields in other treatments, resulting in a value over 100.

The amount of triple superphosphate giving the highest yield, according to unadjusted figures, was considered the optimum phosphate application. For a discussion of this method; see Roorda van Eysinga (1971a).

Table 2. Some important soil analysis figures (P-water and P-AL in mg $P_2O_5$/100 g dry soil).

| Trial | pH-$H_2O$ | pH-KCl | $CaCO_3$ (%) | Organic matter (%) | Clay (< 2 $\mu$m) (%) | P-water | P-AL |
|---|---|---|---|---|---|---|---|
| W 31 | 7.0 | 6.8 | 1.7 | 6.6 | 4 | 3.8 | 122 |
| FPA | 7.5 | 6.6 | 0.9 | 0.4 | 2 | 0.7 | 19 |
| FPB | 7.5 | 7.2 | 3.7 | 6.1 | 22 | 0.4 | 42 |
| FPC | 8.1 | 7.9 | 6.4 | 0.8 | 1 | 0.4 | 9 |
| HPA | 8.1 | 8.0 | 5.3 | 0.9 | 1 | 0.2 | 8 |
| IB 1280 | 6.7 | 6.5 | 0.2 | 9.0 | 27 | 1.9 | 76 |
| vtH | 6.4 | 5.9 | 0.1 | 2.4 | 8 | 4.0 | 142 |
| Zw | 6.8 | 6.8 | 6.7 | 6.3 | 18 | 6.7 | 256 |
| So | 6.9 | 6.9 | 2.9 | 5.4 | 16 | 15.0 | 368 |
| PNL | 6.5 | 6.3 | 0.2 | 5.4 | 11 | 4.7 | 136 |
| vdE | 6.6 | 6.5 | 0.3 | 1.9 | 7 | 4.4 | 105 |

## 3 Results

### 3.1 Crop response

Of the eleven trials, two were carried out in newly-built glasshouses on a sandy soil excavated from the subsoil (Schrader & Schonewille, 1965). On this soil, with a very low phosphate level, the crop responded very strongly when triple superphosphate was applied.

Apart from temporary purple veins on the lower side of young leaves, there were no distinct deficiency symptoms in the unfertilized plots. But the plants remained small and their stems were thin. Plots with and without phosphate differed greatly giving very low relative yields. The other trials did not show clear differences so that their relative yields were mostly close to 100 (see Fig. 1 and 2).

The relation between relative yield and P-water could be described by the regression equation

$y = -14/x + 103$, in which y = relative yield and x = P-water

$(r = -0.77^{++})$;

for P-AL the regression equation

$y = -667/x + 106$ and $r = -0.97^{++}$ was calculated.

From these equations the threshold values, the values above which phosphate must not be applied, can be calculated by putting relative yield equal to 100. A relative yield of 100 means there is no change in crop yield when phosphate is

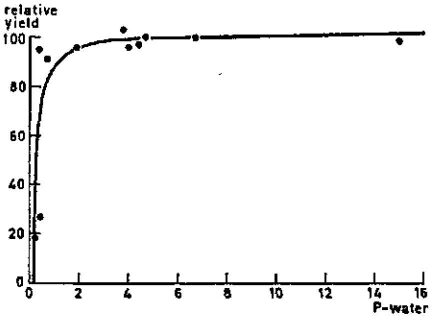


Fig. 1. Relation between relative yield and P-water.

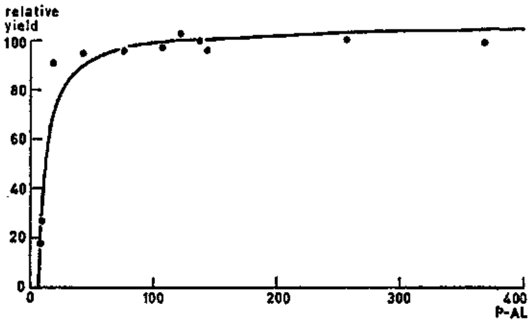


Fig. 2. Relation between relative yield and P-AL.

applied. The threshold value calculated for P-water was 5.0, with 0.8 and $\infty$ being the confidence limits; for P-AL 112, with 57 and $\infty$ ($P = 0.05$). These values are lower than those for lettuce (Roorda van Eysinga, 1971a), where P-water was 7 and P-AL 150. The threshold value P-AL = 112 agrees well with the P-AL = 125 found by Van der Boon (1960) for outdoor vegetable crops.

## 3.2 Fruit quality

In literature reference was made to phosphate and quality by Winsor & Long (1967), who found a negative influence of phosphate on fruit quality but also a significant interaction of potassium; at the highest potassium level there was a very small phosphate effect. The negative influence of phosphate found by Kidson & Stanton (1963) was especially at low nitrogen and potassium levels. Woods (1964) found a significant influence on quality (more blotchy) in one year, but not significant in two other years. According to Woods, heavier fruiting would increase quality disorders.

In accordance with these data the influence of applied phosphate on the percentage by weight of evenly coloured fruits (quality 'Extra') was significantly negative from statistics in only one of the trials (FPC), and on the average the difference was zero or very close to it (see Table 3).

This means that compared with nitrogen and potassium, the influence of phosphate is of little importance.

Table 3. Percentages evenly coloured fruits (quality 'Extra').

| Trial | Quantity of triple superphosphate in kg per 100 m² | | | |
|---|---|---|---|---|
| | 0 | 5 | 10 | 20 |
| W 31 | 84 | 79 | 76 | 72 |
| FPA | 94 | 97 | 95 | 97 |
| FPB | 78 | 81 | 81 | 81 |
| FPC | 92 | 86 | 82 | 85 |
| HPA | 70 | 72 | 77 | 74 |
| IB 1210 Maascross | 98 | 97 | 97 | 99 |
| Extase | 96 | 95 | 95 | 95 |
| vtH | 91 | 92 | 93 | 91 |
| Zw | 88 | 85 | 89 | 87 |
| So | 94 | 93 | 94 | 93 |
| PNL | 97 | 97 | 97 | 96 |
| vdE | 99 | 99 | 99 | 99 |
| Mean | 89.5 | 88.8 | 89.0 | 88.4 |

In trial FPC there was a significant ($P = 0.01$) quadratic effect; in the other trials the effects were not significant.

### 3.3 Diseases

In most trials the percentage of fruitfall due to *Botrytis* was very low (less than 1 %). In one trial (vdE) the percentage varied from 1 to 2 %, in an other (FPB) it was about 5 %. Applied phosphate did not clearly affect this percentage. In previous experiments a decrease in fruitfall by nitrogen was found (Roorda van Eysinga, 1971b).

### 3.4 Leaf analysis

In two trials (see Table 5) applying triple superphosphate distinctly increased the phosphate content of the leaves, in the others there was little or no reaction.

Applied phosphate had no distinct influence on potassium ($K_2O$ on dry matter ranging from 2.81 till 7.42 %), calcium (from 5.16 till 9.37 % CaO), sodium (from 0.10 till 1.24 % $Na_2O$).

The magnesium content of the dry matter decreased only in the strongly reacting trials: in trial FPC (from 2.07 till 1.04 % MgO), in trial HPA (from 2.95 till 2.06 % MgO); in the other trials the magnesium content was on the average lower (from 0.72 till 1.40 %).

In the strongly reacting trials the nitrate content increased (on trial FPC from 0.31 till 0.55; on trial HPA from 0.87 till 1.07 % $NO_3$-N); in some of the other trials there was also an increase (the nitrate content varied between 0.21 till 1.63 %).

A positive correlation was observed between nitrate and phosphate contents of leaves in the stronger reacting trials. If the results of all trials were considered, the same correlation was more evident and detectable over a longer range. This could not be explained, however.

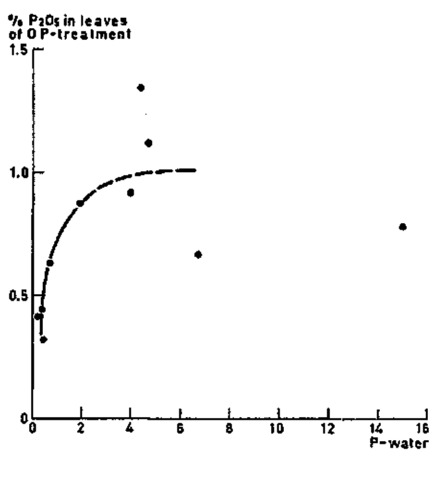


Fig. 3. Relation between phosphate content of leaves (% $P_2O_5$ in dry matter) of O P-treatment and P-water.

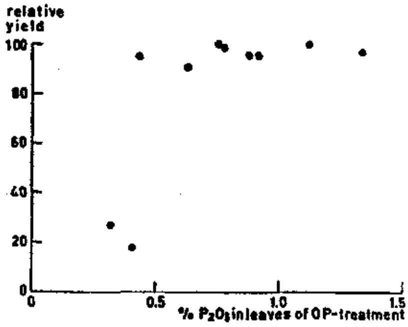


Fig. 4. Relation between relative yield and phosphate content of leaves (% $P_2O_5$ in dry matter) of O P-treatment.

A relation between phosphate content of the soil and that in the leaves of the O P-treatment was found (see Fig. 3), but this relation disappeared at higher phosphate status. By plotting relative yield against the phosphate content in the leaves of the O P-treatment a fair correlation was found (see Fig. 4), and the threshold value of leaf phosphate was calculated to be 1.01 % $P_2O_5$ on dry matter.

## 3.5 Optimum triple superphosphate application

As in the study of lettuce, phosphate content of the soil was not related to optimum application of triple superphosphate. This may be explained by the use of unadjusted yield data to determine the optimum application; in cases of high phosphate content and no or small plant response to phosphate – assuming that excess phosphate does not harm growth and yield – small differences in yield may lead to large differences in the estimates of the optimum phosphate application. As high phosphate doses were not detrimental for tomatoes at high phosphate level of the soil, all used phosphate rates can therefore occur as optimum and the relation with the soil analysis figures was lost, as was the case for lettuce, reported in a previous paper by the author (1971a).

It can only be said that above the calculated threshold value (P-water 5) no phosphate must be added and at very low phosphate levels (P-water about 0) 20 kg triple superphosphate per 100 $m^2$ is needed.

## 3.6 Phosphate effect of farmyard manure

In two newly-built glasshouses on poor soils the application of triple superphosphate was studied in factorial combination with and without manure as farmyard manure and in one trial as slurry. Crop nutrition with nitrogen and potash was kept as equal as possible for all treatments with different mineral fertilizers. In trial FPC 1500 kg FYM was applied, in trial HPA 1000 kg FYM and 2000 l slurry (all per 100 $m^2$). The percentages of some important components of the manures are given in Table 4. The manure had a normal composition, but the phosphate contents were higher and the potassium content of the slurry was lower than

Table 4. Percentages of some important components of the manure (on fresh weight).

| | Trial FPC | Trial HPA | |
|---|---|---|---|
| | FYM | FYM | slurry |
| Moisture | 76 | 74 | 93 |
| Organic matter | 16 | 12 | 5 |
| Total N | 0.5 | 0.6 | 0.4 |
| $P_2O_5$ solube in mineral acid | 0.52 | 0.41 | 0.27 |
| $K_2O$ soluble in water | 0.45 | 0.48 | 0.25 |

normal (see Kolenbrander & de la Lande Cremer, 1967).

The yields in both trials are respresented in Figure 5. The differences in yield between applying mineral and organic fertilizers, the influence of phosphate and the interaction were statistically significant. The influence of triple superphosphate application was statistically not significant when manure was applied, as it was with mineral fertilizer. The phosphate content of the leaves, as they are affected by triple superphosphate in combination either with mineral fertilizers or manure, are reproduced in Table 5. An important effect of phosphate from manure is shown by the contents of leaf phosphate. Considering yield figures (see Fig. 5) the effect of phosphate from manure was estimated to range from 50 till 200 %, compared with mineral phosphate.

If manures are used the application of mineral phosphate has to be reduced with at least half the amount of phosphate applied with the manure.

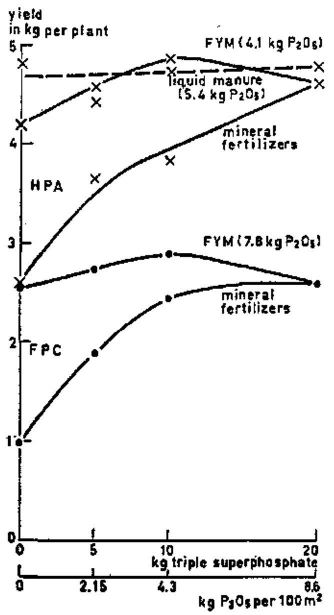


Fig. 5. Influence of triple superphosphate dressings with and without manure on yield in trials HPA and FPC.

Table 5. The influence of triple superphosphate (kg/100 $m^2$) dressings, with and without manure, on percentage phosphate in leaves ($P_2O_5$ in dry matter).

| | Trial FPC | | Trial HPA | | |
|---|---|---|---|---|---|
| | with mineral fertilizers | with FYM | with mineral fertilizers | with FYM | with slurry |
| 0 | 0.32 | 0.85 | 0.41 | 0.99 | 0.94 |
| 5 | 0.48 | 0.93 | 0.56 | 1.05 | 1.08 |
| 10 | 0.51 | 0.99 | 0.70 | 1.10 | 1.22 |
| 20 | 0.59 | 1.12 | 1.03 | 1.32 | 1.38 |

## Summary


Eleven trials with several tomato varieties in commercial glasshouses and with different soil phosphate levels are described. Each trial involved 0, 5, 10 and 20 kg triple superphosphate (43 % $P_2O_5$) per 100 $m^2$. In two trials manure was applied.

The threshold value, the phosphate content of the soil above which applied phosphate does not give a higher yield, corresponded with P-water 5.0 and P-AL 112.

In newly-built glasshouses on poor soils 20 kg triple superphosphate per 100 $m^2$ is the optimum. Where manure is applied, the optimum amount of triple superphosphate must be reduced with at least half the amount of phosphate applied with the manure.

Phosphate has practically no influence on fruit quality.


## Samenvatting


Beschreven worden 11 proefvelden met diverse tomaterassen, aangelegd in kassen op tuindersbedrijven verschillend in bodemvruchtbaarheidstoestand. Elk proefveld omvatte vier fosfaattrappen, te weten: 0, 5, 10 en 20 kg dubbelsuperfosfaat (43 % $P_2O_5$) per are. Op 2 proefvelden werd nog een bemesting met (stal)mest in het proefschema opgenomen.

Berekend werd als grenswaarde waarboven de fosfaatbemesting moet worden weggelaten: P-water 5,0 en P-AL 112.

In nieuwe kassen op arme grond bleek 20 kg dubbelsuperfosfaat per are de optimale gift.

Bij gebruik van stalmest moet de optimale gift dubbelsuperfosfaat worden verminderd met ten minste de helft van de hoeveelheid fosfaat via de mest toegediend.

Fosfaat heeft vrijwel geen invloed op de kwaliteit van de tomatevrucht.

**Zusammenfassung**

Beschrieben werden 11 Parzellenversuche mit verschiedenen Tomatensorten, durchgeführt in Gewächshäusern unterschiedlich in Bodenfruchtbarkeit. Jedes Parzellenversuch umfaszte vier Phosphorsäuredüngungsgaben: 0, 5, 10 und 20 kg Doppelsuperphosphat (43 % $P_2O_5$) je Ar.

In 2 Parzellenversuchen wurde noch eine Düngung mit Mist im Versuchsprogramm aufgenommen.

Als Grenswerte, worüber hinaus die Düngung mit Doppelsuperphosphat hinterlassen werden soll, wurden gefunden: P-wasser 5,0 und P-AL 112.

In ganz neuen Gewächshäusern auf arme Boden entspricht 20 kg Doppelsuperphosphat je Ar die Optimalgabe.

Beim Anwendung von Mist ist die Optimalgabe von Doppelsuperphosphat zu verminderen mit am Wenigsten der Hälft der Phosphorsäure in Mist anwesend.

Phosphorsäure hat keinen besonderen Einflusz auf die Qualität der Tomatenfrüchte.

## Literature


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