SUBSTRATES AND FERTILIZATION OF POT PLANTS

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INTRODUCTION

Up till now, research work done on substrates for potplants, was chiefly restricted to a study of the substrate as a separate factor.

The investigations made by DÄNHARDT AND KÜHLE [1] principally aimed at proving the positive effect of a rise of the peat content in a mixture consisting of clay and peat.

Also in the experiments carried out by BUNT [2] the starting-point was to demonstrate the fact that an improvement of the physical condition of the potting-soil resulting from an addition of peat would have a favourable influence on the growth of the crop.

In an experiment made by ourselves [3] with mixtures of clay and peat at various ratios, a similar result was obtained, at least during the first experimental stage.

For towards the end of the growing period the reverse was noticed. In that stage the mixtures rich in clay, proved to be better than those rich in peat. There were however indications, that in the latter stage the nutritional condition of the potting-soil was closely connected with this development. Plants on mixtures rich in peat, which at first had been ahead of the other ones, now showed obvious symptoms of nitrogen deficiency. On the other hand these deficiency symptoms did not occur at all in plants on mixtures rich in clay. We must bear in mind that in all these test-mixtures the fertilization had been exactly the same.

On account of the facts recorded it was assumed that in potplants there is obviously a close connection between the factors substrate and fertilization.

The following experiments aimed at studying this problem further.

I. *Substrate-nitrogen fertilization trial with Cyclamen*

EXPERIMENTAL

Combinations of 5 substrates (in volume parts) and 5 nitrogen levels.

Substrates : S 1 5 p. of clay + 1 p. of peat
S 2 5 p. of clay + 1 p. of farmyard manure
S 3 1 p. of clay + 5 p. of peat
S 4 1 p. of clay + 4 p. of peat + 1 p. of farmyard manure
S 5 Aalsmeer mixture (standard).

From 1 February-28 April the plants were kept in small pots (size 280 ml), from 29 April until the end of the experiment in large pots (size 900 ml).

A. *Small-pot stage*

Nitrogen levels : 40, 160, 360, 640 and 1000 g of N per m^3 applied as nitrochalk.

B. *Large-pot stage*

Nitrogen levels : 80, 320, 720, 1280 and 2000 mg of N per pot.

Other fertilizers were added in sufficient amounts. The pH-water of the substrates varied between 6.8 abd 7.3 It should be mentioned that all the test-plants of treatment S_1N_5 and the greater part of the plants of S_2N_5 had fallen out before the end of the experiment on account of salinity injury.

Variety : Vuurbaak.

The experiment was carried out according to a lattice-design with 4 replications and 6 plants per replication.

Results

Physical properties of the test mixtures

Table 1 renders the principal physical properties of the 5 mixtures.

Table 1. — Physical properties of the 5 test substrates

substrate	ratio at pF 1,5			total porosity vol. %	volume weight dry soil g/100 ml	available water pF 1,5-4,2 vol. %
	soil vol. %	water vol. %	air vol. %			
S_1	33,0	41,0	26,0	67,0	84,8	24,2
S_2	32,8	38,7	28,5	67,2	84,1	23,4
S_3	15 5	55,8	28,7	84,5	35,4	39,4
S_4	15,6	59,8	24 6	84 4	34,5	43,1
S_5	22,2	48,0	29,8	77,8	53,0	27,5

The soil : water : air ratio was chosen at pF 1,5 according to measurements during the cultivation period. The moisture-condition of the surrounding peat medium of the pots normally fluctuates about this value.

It was found that a rise of the peat content influenced the physical properties of the mixture in the following way : a sharp reduction of the volume of solid soil particles, a rise of the moisture-volume, a rise of the total-pore content, a reduction of the volume weight and a rise of the available water content. On the other hand the air-volume, which in all cases could be considered to be amply sufficient, practically did not alter.

With respect to plant growth the rise of the moisture-volume may be considered to be the principal improvement of the physical condition of the substrate.

Response of plant growth to the treatments.

A. *Small-pot stage*

Table 2 shows the results of a number of growth measurements carried out at the end of the small-pot stage.

TABLE 2. — Influence of substrate and nitrogen fertilization on the growth of Cyclamen measured as young plants

		vigour markings	plant diameter cm	number of leaves per plant	colour of leaves	fresh leaf weight per plant g	fresh tuber weight per plant g
substrate	S_1	3,5	12,0	10,1	6,7	7,2	4,3
	S_2	4,7	13,5	13,3	7,1	13,6	5,0
	S_3	6,4	14,8	15,6	6,9	21,4	5,1
	S_4	6,3	14,3	15,9	7,2	20,1	4,7
	S_5	6,1	14,1	16,0	6,8	18,8	4,3
$(S_3 + S_4) - (S_1 + S_2)$ *		++	++	++	o	n. d.	n. d.
$S_2 - S_1$		++	++	++	++	n. d.	n. d.
$S_4 - S_3$		o	++	o	o	n. d.	n. d.
N fertilization	N_1	4,9	13,3	13,9	4,6	11,3	7,2
	N_2	6,0	14,6	15,9	6,4	16,9	5,8
	N_3	6,0	14,3	15,8	7,6	20,2	3,9
	N_4	5,5	13,8	13,6	7,9	19,5	3,5
	N_5	4,5	12,7	11,6	8,3	13,2	3,0
NL		++	++	++	++	n. d.	n. d.
NQ		++	++	++	++	n. d.	n. d.
Interactions : SxNL **		++	o	+	++	n. d.	n. d.
SxNQ		++	++	++	++	n. d.	n. d.

* n. d. = not determined ; o = not significant ; + = significant at P = 0,05 ; ++ = significant at P = 0,01.

** S = (S3 + S4) — (S1 + S2).

This table shows that mixtures rich in peat (S_3 and S_4), setting aside leaf colour and fresh tuber weight, have obviously given a much better result than mixtures rich in clay (S_1 and S_2). This agrees with the results of the experiments mentioned before [1, 2, 3].

Of the two mixtures rich in clay, the one with farmyard manure (S_2) was better than that without manure (S_1).

On the other hand, of the two mixtures rich in peat the mixtures with farmyard manure (S_4) was significantly worse than the one without (S_3), at least judging from the plant diameter.

Also the beneficial nitrogen effect was obvious for all properties, except the fresh tuber weight ; the optimum appeared to lie at the 2nd or 3rd nitrogen level. A further increase of the nitrogen dressing was followed by a decline, which must be ascribed to a too high salt content in the potting soil. The fresh tuber weight already drops at N_1.

In view of the aim of the experiment the principal result is, however, the occurrence of an outstanding substrate $\times$ nitrogen interaction, which proved to be significant for the vigour markings, plant diameter, number of leaves per plant and leaf colour at $P = 0{,}01$.

To illustrate the nature of the $S \times N$ interaction the number of leaves per plant has been set out against nitrogen levels in a diagram for each of the test-substrates (fig. 1). For that purpose the applications of nitrogen were converted into mg per pot.

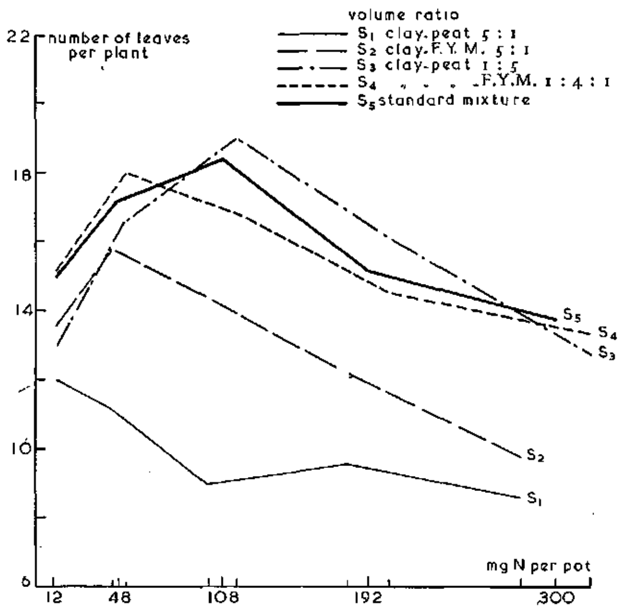

FIG. 1. — Diagram of number of leaves in relation to N rate for each of the five test — substrates (Cyclamen, small-pot stage)

It may be concluded from the diagram that a rise of the peat content in the mixture will make the nitrogen effect more positive, at least in the range N_1-N_3.

This $S \times N$ interaction was also shown for the fresh tuber weight (fig. 2) : the negative nitrogen effect was stronger in mixtures rich in peat than in the ones rich in clay.

B. *Large-pot stage*

The data concerning vegetative growth and flowering qualities determined on mature plants are presented in summarized form in table 3.

As to the substrate effect it may be observed, that the figures of table 3 completely confirm those of table 2.

Moreover, a rise of the peat content in the mixture appeared to have had a positive influence on the flowering qualities.

The influence of farmyard manure was entirely the same as during the early stage : favourable in mixtures rich in clay, unfavourable in the ones rich in peat.

As to the nitrogen effect for the vegetative qualities the optimum lay at N_3, for the flowering qualities and earliness of flowering however at N_2.

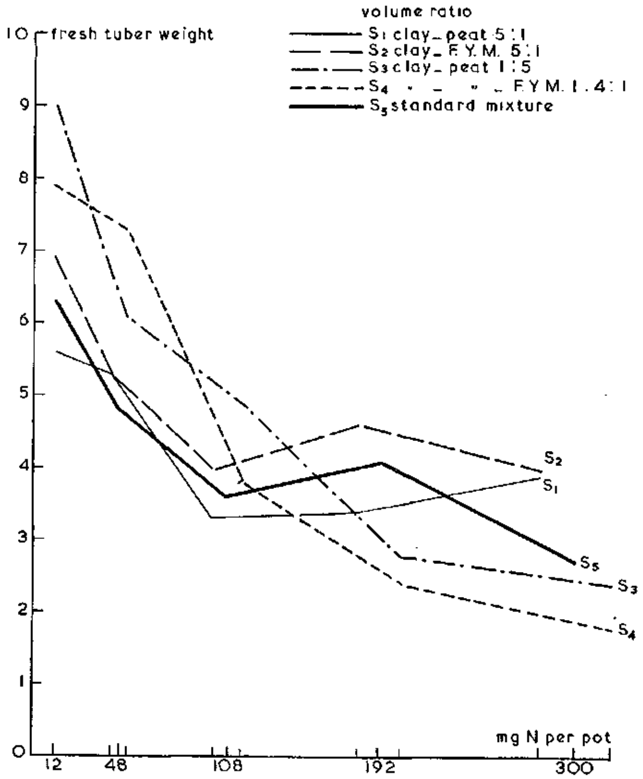

Fig. 2. — Diagram of fresh tuber weight in relation to N rate for each of the five test — substrates (Cyclamen, small-pot stage).

Exactly the same S × N interaction, as found in the early stage, appeared to exist in full-grown plants. To illustrate this, for each substrate the plant diameter has been set out graphically against the nitrogen dressing (fig. 3).

As appears from table 3, the S × N interaction also holds good for flowering-quality and earliness.

TABLE 3.
Influence of substrate and nitrogen fertilization measured on mature plants

		vigour markings	plant diameter cm	number of leaves per plant	number of flowers and buds above leaf crown	number of buds under leaf crown	earliness of flowering
substrate	S_1	5,3	24,9	44,6	5,4	31,7	6,6
	S_2	5,6	25,6	51,8	6,5	36,8	7,7
	S_3	6,9	28,5	68,8	8,7	45,3	8,3
	S_4	6,0	28,1	62,1	7,6	43,9	7,1
	S_5	5,8	27,6	61,7	6,8	45,9	7,0
$(S_3 + S_4) - (S_1 + S_2)$		++	++	++	++	++	o
$S_2 - S_1$		o	++	++	+	+	++
$S_4 - S_3$		++	++	++	+	o	++
N fertilization	N_1	4,7	22,7	47,8	6,8	36,5	7,4
	N_2	6,7	27,0	63,8	7,6	46,6	8,3
	N_3	6,6	29,6	65,6	7,2	44,0	7,5
	N_4	5,6	28,4	54,1	6,3	35,8	6,2
	N_5 *	4,3	25,5	41,7	3,1	27,0	4,2
NL		++	++	++	++	++	++
NQ		++	++	++	++	++	++
Interactions : SxNL		o	++	o	+	o	o
SxNQ		+	o	++	++	o	+

* Average of only S3, S4 and S5 (S1 having fallen out and S2 being too incomplete.)

II. *Substrate-nitrogen fertilization trial with Gloxinia*

EXPERIMENTAL

Combinations of 4 substrates (in volume parts) and 4 nitrogen levels.

Substrates : S 1 3 p. of clay + 3 p. of " gardenpeat "
S 2 1 p. of clay + 5 p. of " gardenpeat "
S 3 " garden peat " (frozen old black sphagnummoor-peat)
S 4 practice-mixture (standard).

The pH of the substrates varied between 5,9-6,7. Nitrogen levels : 80, 240, 480 and 720 g of N per m^3 applied as nitrochalk. Other fertilizers were added in sufficient amounts.

The experiment started on February 21st 1961 and was terminated on June 26th 1961. It was carried out according to a 4 × 4 lattice design with 4 replications, each with 4 plants.

Results

Physical properties of the test-mixtures

In table 4 the principal properties of the test-mixtures are given.

TABLE 4. — Physical properties of the four test-mixtures

substrate	ratio at pF 1,5 soil vol. %	ratio at pF 1,5 water vol. %	ratio at pF 1,5 air vol. %	total porosity vol. %	volume weight dry soil g/100 ml	available water pF 1,5-4,2 vol. %
S_1	22,4	47,8	29,8	77,6	54,4	32,8
S_2	13,8	55,6	30,6	86,2	29,0	39,2
S_3	9,0	56,3	34,7	91,0	14,8	43,1
S_4	16,2	41,6	42,2	83,8	35,9	29,9

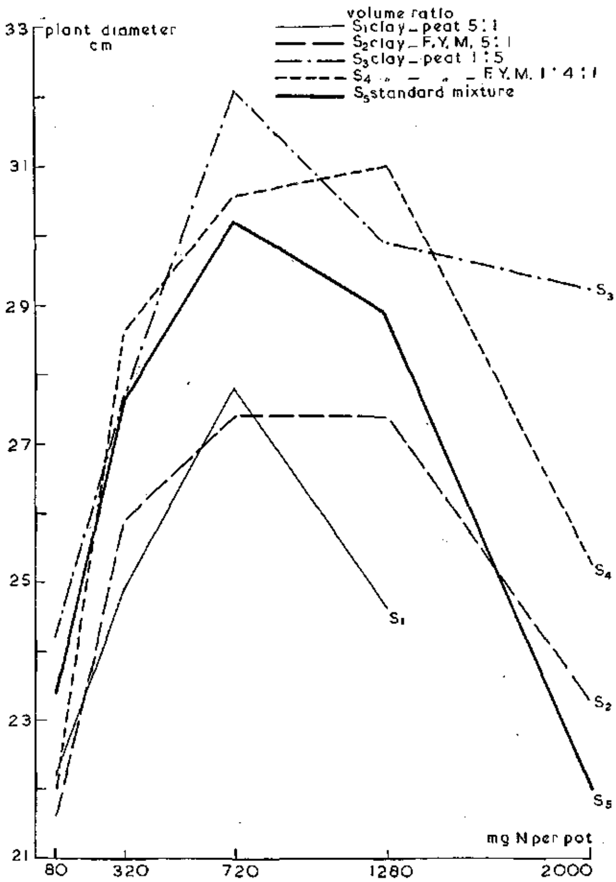

FIG. 3. — Diagram of plantdiameter in relation to N rate for each of the five test — substrates (Cyclamen, large-pot stage)

Shifting the clay- " garden peat " ratio from S_1 to S_3 appears to result into a reduction of the volume of solid soil particles, a rise of the moisture-volume, a slight rise of the air-volume, a rise of the total porosity, a sharp decrease of the volume-weight and a rise in the available water content.

Response of plant growth to the treatments

Table 5 renders the influence of substrate and nitrogen fertilization on vegetative growth and flowering quality of Gloxinia as determined on the mature crop.

In general the mixtures rich in " garden peat " (S_2 and S_3) appeared to have given the best results ; no difference was found between S_2 and S_3. For Gloxinia it turned out to be quite indifferent whether a mixture of 1 part of clay and 5 parts of " garden peat " is used or pure " garden peat ", which is in contradiction with the results found by DÄNHARDT AND KÜHLE [1].

For most properties the nitrogen optimum lay at N_2, for earliness of flowering, however at N_1. A further increase of nitrogen caused a drop as a result of excess of soluble salts in the soil.

TABLE 5. — Influence of substrate and nitrogen fertilization on growth and flowering-quality of Gloxinia

		vigour markings	plant diameter cm	width of largest leaf cm	length of largest leaf cm	leaf colour	number of flowers and buds per plant	earliness of flowering
substrate	S_1	5,5	40,5	14,6	18,0	7,0	20,6	6,9
	S_2	6,1	48,4	17,4	21,4	7,4	24,9	8,2
	S_3	6,3	47,6	17,3	21,3	7,5	25 5	8,0
	S_4	5,9	42,3	14,7	19,0	7,8	24,0	6,7
$2S_1 - (S_2 + S_3)$		++	++	++	++	++	++	++
$S_3 - S_2$		o	o	o	o	o	o	o
$3S_4 - (S_1 + S_2 + S_3)$		o	++	++	++	++	o	++
nitrogen	N_1	5,8	48,1	17,8	21,8	5,6	24,0	8,7
	N_2	6,4	48,8	17,4	21,7	7,2	25,6	8,5
	N_3	6,0	44,0	15,4	19,4	8,1	23,3	7,5
	N_4	5,5	37,7	13,4	16,8	8,4	22,0	5,2
N_L		++	++	++	++	++	++	++
N_Q		++	++	++	++	++	++	++
interactions : $S \times N_L$ *		++	++	++	++	o	+	++

* $S = 2\,S_1 - (S_2 + S_3)$.

In view of the aim of the experiment, however, the principal point is, that here also a significant $S \times N$ interaction was found ($P = 0{,}01$).

To illustrate this $S \times N$ interaction, for each substrate the plant diameter has been set out graphically against the nitrogen dressing (fig. 4). First of all it is obvious, that the fall in growth when raising the nitrogen dressing above the optimum (i. e. the negative salt-effect) was slighter, as the mixture contained more " garden peat ". This is in agreement

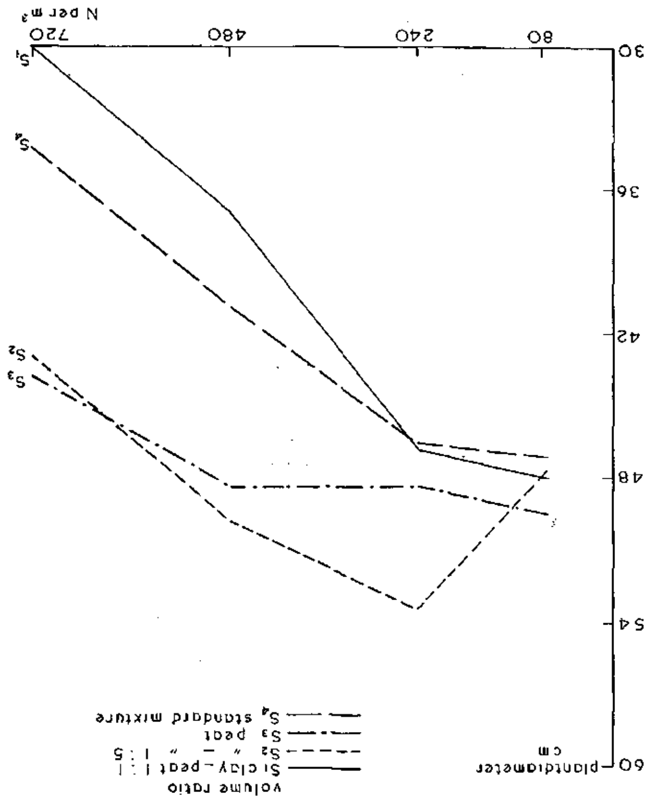

FIG. 4. — Diagram of plantdiameter in relation to N rate for each of the four test-substrates (Gloxinia)

with the opinion of VON HÖSSLIN AND PENNINGSFELD [4], that a higher content of organic matter in the potting soil will reduce the chance of salinity injury. " Garden peat " (S_3) proved to be remarkably indifferent to an excess.

Another facet of the interaction is that a rise of the nitrogen dressing in the range N_1-N_2 led to an improvement of S_2, whereas in S_1, S_3 and S_4 a slight fall was found.

DISCUSSION

In the first place it may be concluded that both experiments demonstrate a close relationship between substrate and fertilization of potplants. For in both a significant $S \times N$ interaction was shown for almost all plant-properties.

This substrate × fertilizing interaction in clay-peat mixtures with nitrogen fertilization can be described as follows.

An increase of the peat-content in the mixture causes an increase of the nitrogen effect at sub-optimum rates or a decrease of the negative salt-effect by excesses.

On account of the reality of this interaction in general a complete insight into the quality of a substrate can only be obtained, if the influence of that substrate on the fertilization effect is also taken into consideration. In other words : the way, in which the substrate determines the fertilization effect, should be considered as one of the most important properties of the substrate.

Hence it follows, that fertilization must be adapted not only to the crop, but also to this property of the substrate. In this connection, the term " fertilization " refers to dose as well as to procedure of fertilization. Mixtures rich in peat require a larger base fertilization and in the case of long-term crops, additional fertilization at more frequent intervals. Cyclamen [3] and carnations [5] appeared to respond much stronger negatively to the absence of a proper supplemental fertilization on substrates rich in peat, than on the ones rich in clay. On the other hand, the positive effect of split vs. single application of fertilizers will find more expression in a substrate rich in clay than in one rich in peat.

This paper has not dealt with the interpretation of the phenomena found. It is assumed, however, that in all these questions the moisture-volume of the substrate has played a predominant part.

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REFERENCES

[1] Dänhardt, W.U. Kühle, G. — *Archiv für Gartenbau*, 1959, 7, 157-174.
[2] Bunt, A.C. — *Plant and Soil*, 1961, **13**, 322-332.
[3] Arnold Bik, R. — *Jaarverslag Proefstation voor de Bloemisterij te Aalsmeer over* 1959, 51-55.
[4] Hösslin, R. von, Penningsfeld, F. U. — *Zeitschr. Pflanzenern. u. Bodenk.*, 1949, **47**, 145-161.
[5] Arnold Bik, R. — *Jaarverslag Proefstation voor de Bloemisterij te Aalsmeer over* 1959, 21-23.

DISCUSSION

Q. — Wasscher (The Netherlands) : Have you found any correlation between the quality of the plants and the keepability ?

R. — The mentioned results goes also for the number of flowers and the earliness of the flowering. Unfortunately, the keepability could not be determined owing to the lack of accomodation.