J. P. N. L. Roorda van Eysinga

Institute for Soil Fertility, Groningen

Development of a pure peat mixture for raising plants with blocks

Ontwikkeling van een potgrond uit veen voor de opkweek van planten in een perspot

Entwicklung eines Torfsubstrates für Jungpflanzenanbau mittels Presstöpfe

pudoc

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Wageningen

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Contents

1	INTRODUCTION	3
1.1	Soil block and its use	3
1.2	Development of the potting soil trade in the Netherlands	6
1.3	Potting soil research in other countries	8
2	INVESTIGATIONS	9
2.1	Introduction to the investigations. Objective of the study	9
2 2	Description of the materials used	10
3	RESULTS	15
3.1	Relationship between plant size and yield	15
3.2	Optimal physical conditions of a potting mixture based on black peat and peat moss	21
3.3	Optimal chemical conditions of a potting mixture based on black peat and peat moss	30
3.3.1	*Nutrients*	30
3.3.2	*Growth stimulators and insecticides*	48
4	FLUJAS MIXTURE	52
4.1	Properties of the Flujas mixture	52
4.2	Introduction of the Flujas mixture	57
5	DISCUSSION AND CONCLUSIONS	58
SUMMARY		61
SAMENVATTING		62
ZUSAMMENFASSUNG		63
LITERATURE		64
APPENDIX. Description of the series		67

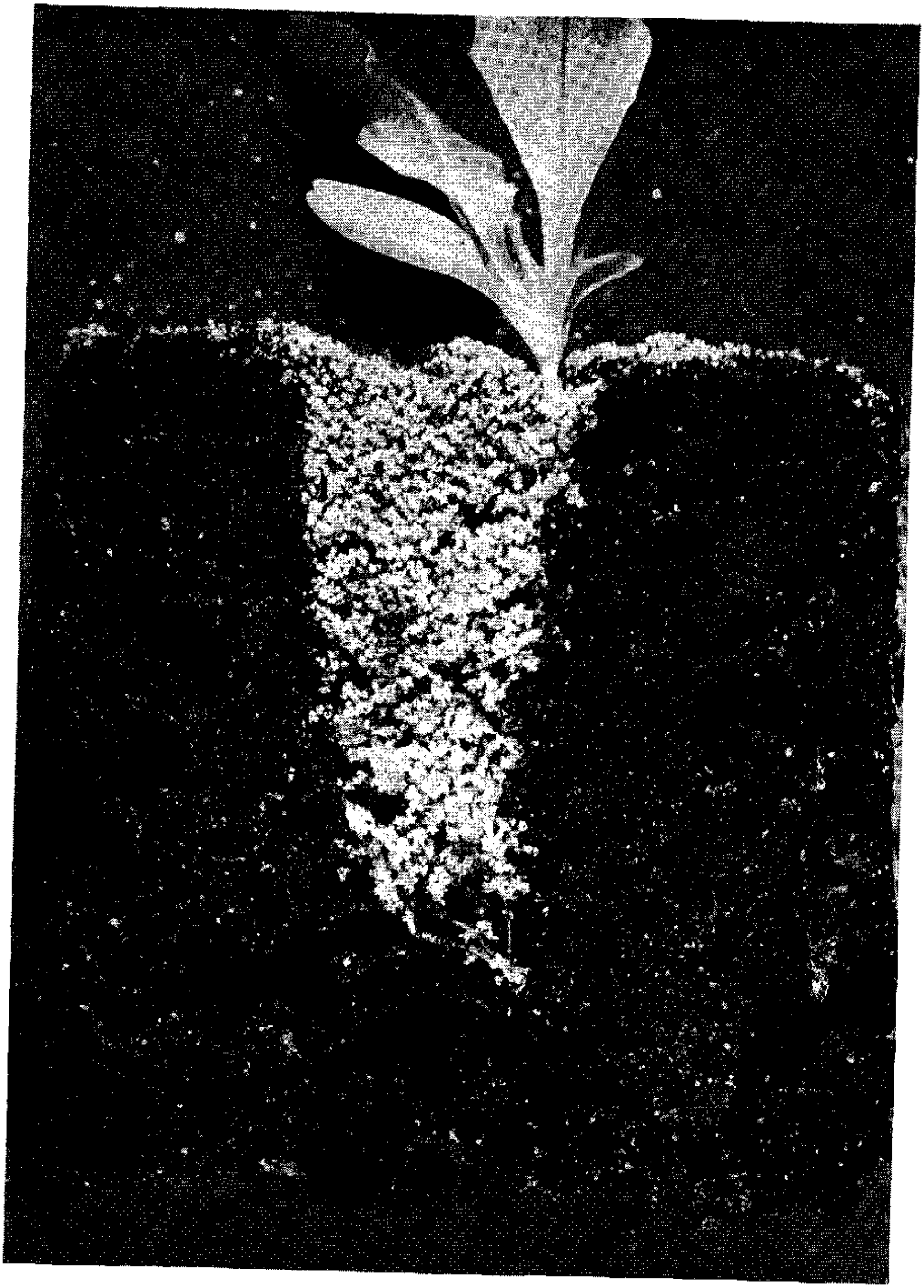


Plate I. Longitudinal section of a soil block with lettuce (approximately by 3)

1 Introduction

1.1 Soil block and its use

In the Netherlands soil blocks are used for raising young plants for vegetable growing. A soil block is a clod made by compressing a quantity of wet potting soil. Soil blocks are mostly cubic, sometimes cylindrical or hexagonal columnar in shape (Plate I). In the middle of the top there is a vertical hollow tapering downwards. The soil block serves as a rooting substratum for plants pricked out into this block, the roots of the seedling being placed in the hollow.

Lettuce and tomatoes are nearly always raised with blocks. Glasshouse cucumbers are partly raised with blocks, partly with clay pots, wire pots, plastic bags and otherwise. Other crops sometimes raised with blocks are cauliflower, red pepper, kohlrabi, gherkins and sporadically cabbage, French beans, broad beans, celeriac and endive and, by way of trial, strawberries.

The alternative to the soil block is:

a direct sowing,

b planting out with bare roots (raising on plant bed),

c planting out with root ball (raising in clay pot or other type of container).

The question which of these possibilities for raising plants is the most suitable has not been investigated by the author because the decision about raising depends on the economic aspects of the nursery.

In the Netherlands soil blocks are generally hand-made by means of a plant tool (Plate II), in contrast to Western Germany, for instance, where the soil blocks are generally machine-made. The latter method of manufacture has the disadvantage of the cost of equipment and the advantage of less physical effort in the manufacture of the blocks. The production rate of machine-made blocks is, if anything, little greater than that of hand-made ones. A new machine came on to the market at the same time when this publication was written. An opinion about this machine which makes more blocs per cycle and so per hour cannot yet be given. Machines that simultaneously make soil blocks and prick out plants are still unsatisfactory in produce. The development of such a machine would be of great importance.

There are other methods of making soil blocks apart from those by plant tool or by soil blocks machine. These systems are based on the principle of putting the potting soil in a layer which is then cut into pieces. Examples of these systems are the Maro press (MAST, 1951) and the EDELSTEIN method (VOGEL und BAUMANN, 1961). The trials relating to cubes of peat, soaked in dung and fertilizer solution (ŠUIN, 1958) can also be classed as one of the systems mentioned above. Jiffy-pots are not a substitute for soil blocks but rather of clay pots.

The plant tool was developed in Western Europe during the period 1930–1940 (ROORDA VAN EYSINGA, 1962). At present there are many models. Depending on the size of the blocks, the plant tools may press out from 1 to 12 blocks a time. For lettuce, blocks with an edge of from 3 to 5 cm are used (12, 9 and 6 blocks pressed out each time), for tomatoes a 5 to 8 cm block is used (4 and 2 blocks each time), for cucumbers a 12 cm block is generally used (1 block pressed out each time).

The soil blocks serve as a rooting substratum for seedlings until they can be planted out in the field. Seeds are only exceptionally placed in the soil block, e.g., gherkins and beans. The depression in the soil block then has a flat, shallow bottom in which a number of seeds are laid, unlike the pricking out method in which only one seedling

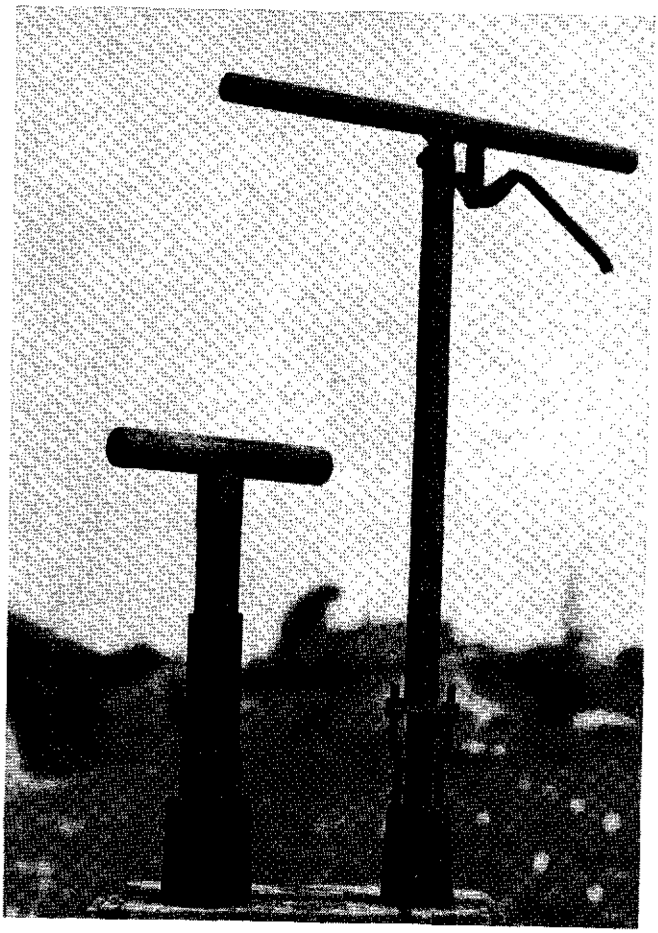


Plate II. Prototypes of plant tools. The left one used in the Netherlands in 1938, the right one developed in Germany in 1939 is used per block. However, there are exceptions, viz. tomatoes and cucumbers, which are grafted. In this case the cultural variety and the rootstock are sometimes pricked out in one block simultaneously to facilitate subsequent grafting.

With tomatoes two blocks, a large and a small one, are sometimes used. The seedling is pricked out into the little block which is later placed into the larger soil block or into a clay pot. More variations can be found in practice.

There are three ways of ensuring that the pricked-out seedling roots firmly in the soil block, viz.:

a closing the planting hole by finger pressure,

b filling the planting hole with dried compost,

c filling the planting hole with dried, coarse sand.

Method (a) is the quickest, but has the disadvantage that the roots of the young plant may be damaged. Method (b) is less suitable because it is more difficult to work with dry compost than with sand and dry compost does not readily absorb moisture. Method (c) is generally preferable except when plants are liable to be turned afterwards by the wind. The wind dries the sand so that the plants may become loose. (Sand has a further advantage of controlling algae growth: sometimes the whole block is covered with a layer of sand. Sand containing disease germs can easily be sterilized by heating, and this dries the sand at the same time. Preliminary trials have shown that it is not necessary to add nutrients to the sand if the potting mixture is a good one.)

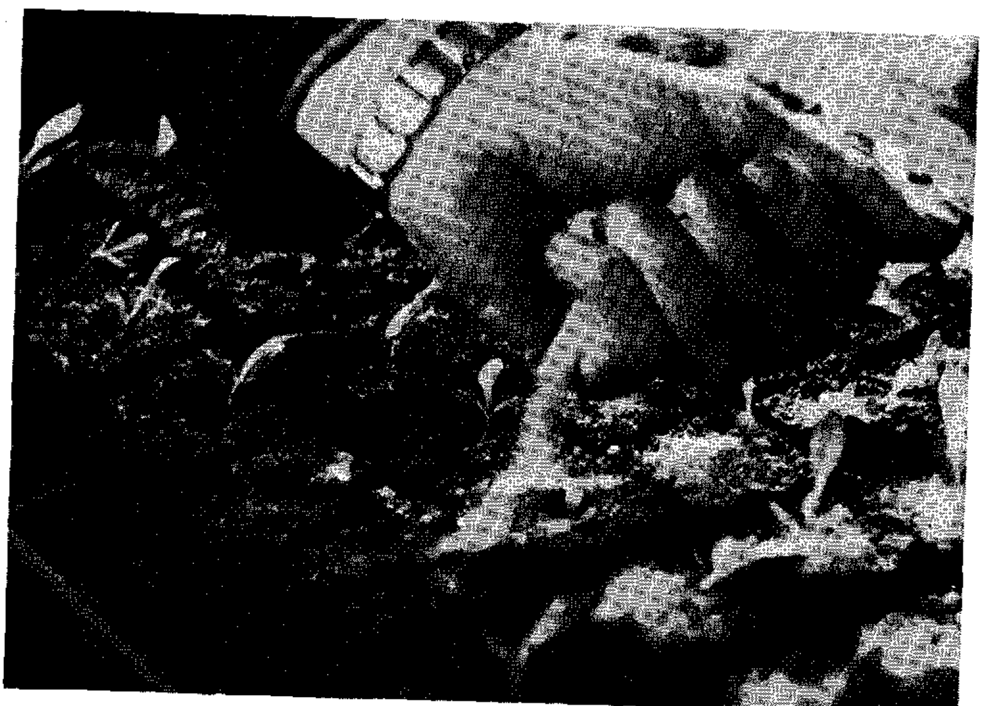


Plate III. Filling the holes of the soil blocks with dry sand

In order to facilitate pricking out, use is often made of iron plates or wooden boxes of from 30 × 40 to 40 × 50 cm. The dimensions of the plate are such that 6, 12 or 20 tools can be emptied on to one plate. A plate filled with soil blocks is easy to handle; the plate can be put on a table, which facilitates pricking out, and after the blocks have been pricked out they can be pushed off the plate onto the plant bed. The blocks containing the pricked-out plants remain in the plant bed until planting-out time (e.g. lettuce): in the case of other crops, e.g. tomatoes, the plants are generally spaced out a few times as the plants grow and develop and impede each other's growth.

When wooden boxes are used the blocks often remain in these boxes during the initial growth period. This is especially the case, with crops that are grown on less extensive scale e.g. red pepper and kohlrabi. Other more labour-saving treatment and methods may be used.

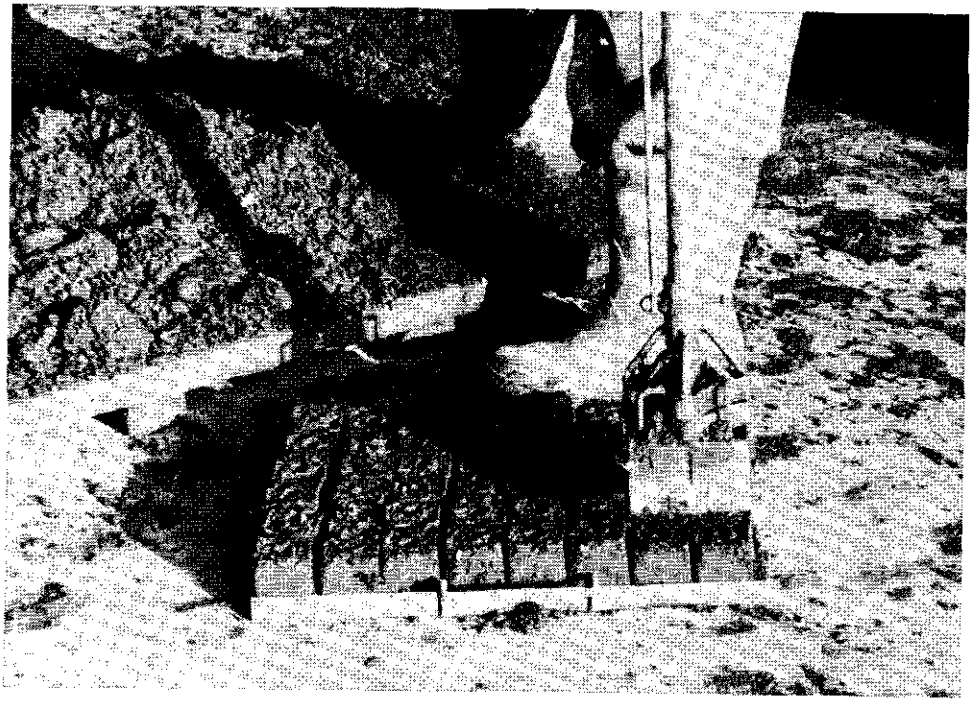


Plate IV. Pressing out of soil blocks with a plant tool on to an iron plate (48 blocks suitable for lettuce on one plate)

1.2 Development of the potting soil trade in the Netherlands

Owing to the expansion of horticulture, especially of vegetable growing under glass and the increasing use of plant tools, there has been a corresponding increase in the demand for potting soil. At first growers made the potting soil themselves. They mixed garden soil with farmyard manure, peat moss, sand and other materials which had to be bought, viz. in the west of the Netherlands, mud and dragpeat dug out of lakes (EGBERTS en VAN DER KLOES 1960), in the Limburg region river loam. An inquiry instilated by the author in 1960 showed that more than fifty per cent of the potting soils were home-made. The bigger part often most of the home-made potting soil consisted of a sandy garden soil. With good nutritional conditions the sandy mixtures gave a reasonably crop growth. A sandy potting soil well-moistured before compressing will produce a good block which can be fairly well handled. As the plant grows, however, the soil block generally dries and may become brittle. Growers should not accept delivery by commercial firms of a potting soil as sandy as the home-made one.

The quality of the potting soil was improved by adding mud-containing materials, which makes the blocks firmer. However, the use of clay-containing muds made the soil blocks too hard when drying, and this impeded rooting. To prevent this more organic material such as peat moss was added.

In addition to the problem of choosing the materials the growers had to find a solution to the problem of nutrient application. Many difficulties in raising plants were due to the application of too much fertilizer to the potting soil.

By increasing demands for potting soil – the author estimated the quantity of potting soil used for raising young vegetable plants in the Netherlands in 1959 to be over 200.000 m^3 each year – the growers created another problem, viz. where to obtain suitable materials for making the potting soil. For this reason the help of tradesmen was increasingly demanded. This development is still continuing. The number of potting soil firms is still increasing.

The trade in organic manures is old, the trade in potting soil developed from the former, is of recent date. One of the oldest firms in the Netherlands (Anes & van der Perk) started the production of potting soil in 1942. Not only did the home-made potting soils cause trouble, but the same was true of the potting soils commercially available to the growers. Nearly every potting soil firm had one or more years in which inferior results were obtained with their potting soils. The reputation of the trade potting soil was so bad that any failure in raising young plants was attributed to the potting soil, whether or not the trouble had another origin. This is of course an undesirable situation because an exact diagnosis is necessary for control and to prevent future trouble. Even in 1959 the advice of the State Advisory Service to growers in the Limburg region was to make the potting soil themselves.

It is better for growers to purchase potting soil than to make it themselves because the trade firms can obtain the materials more easily and can mill and mix them better when using suitable machinery. Buying from such a factory also saves labour in the nursery. As a result of continual experimentation trade potting soil has improved in quality.

Research in potting soil for raising vegetables in the Netherlands is now done at the Horticultural Research and Experiment Station, Naaldwijk (L. S. SPITHOST) and previously at the "Noord-Limburg substation, Venlo. The latter is reported on in the present publication. The research in potting soils for flowers and pot plants at the Experiment Station for Floriculture, Aalsmeer (R. ARNOLD BIK) should also be noted.

1.3 Potting soil research in other countries

In the United Kingdom research has been undertaken by W. J. C. LAWRENCE of the John Innes Institute, resulting in the development of the J.I.P. compost. Of more recent date are the investigations of BUNT.

In Germany research has been carried out by FRÜHSTORFER, who developed his "Einheitserde". In the USA potting mixtures based on peat moss and sand in different ratios are standardized by the U.C.-system (BAKER 1957). The literature is reviewed by SUTTON (1958). This author, however, does not mention the research work done in Germany with pure peat potting mixtures. PENNINGSFELD, who has succesfully grown plants in peat substratum, has also carried out some important investigations. Nor is there any mention of the work done by REEKER (1957) which resulted in the development of TKS-Ballen, balls of peat moss ready for use after the addition of nutrients. With the exception of TKS-balls these potting mixtures are specially intended and developed for growing pot plants. Only the use of J.I.P. compost for the making of soil blocks is described (LAWRENCE 1948).

Generally speaking, the investigations resulted in the development of a standard mixture, sometimes in scientific knowledge of the optimum chemical conditions required, but they yielded little or no information for an exact description of the physical conditions required. The research work reported here is also deficient in this respect.

2 Investigations

2.1 Introduction to the investigations. Objective of the study

The preliminary investigation started in the winter 1957/'58 (series A). As the differences in the yield in the series A were very high (with lettuce a 25% heavier mean head weight, with tomatoes even a 36% heavier yield of fruits for the best potting soil against the worst potting soil), the investigations were started on a large scale in the autumn of 1958.

The investigation can be subdivided into different series, each including a number of potting mixtures. With most of the series one or more crops were cultivated at least until the plants had reached the planting-out stage, in some series the yields were estimated. A review of all the series and of the detail problems that were studied and of the crops that were tested are summarized in the Appendix. The materials used in this investigation are described in 2.2.

The general objective of the study is: how to obtain a good potting mixture for raising young vegetable plants with soil blocks, using materials which will be available in sufficient quantities in the years to come. This general objective was subdivided in the different series. The differences observed in plant growth were studied. Where possible, explanations were found for these differences. There was also an attempt to estimate the percentages of the chemical and physical qualities of the soil.

With some exceptions, the plants raised with soil blocks, agreed with the general statement of the studied objective. For lettuce a 5 cm soil block was used, for tomatoes a 8 cm block, for cauliflower a 6 cm, for cucumbers and strawberries a 12 cm soil block. The soil blocks were approximately cubic.

Apart from some exceptions that are clearly mentioned, seedlings were used for pricking out, at least seedlings which had not been previously pricked out. For strawberries runner plants were used.

If not mentioned otherwise the planting hole of the soil block is filled with dried non calcareous coarse river sand to which no nutrients were added. Although various lots of sand were used, they all came from the same origin so that there will be little difference between the samples of the various lots and the figures given in table 2.

Strawberries are an exception. With strawberries the planting hole is closed by finger pressure as filling up with sand was impossible owing to the many roots of the strawberry runner plants.

In every series each potting mixture appeared only once. From each heap of potting mixture soil blocks were made and placed on one or more iron plates (Plate IV). On these plates could be placed 48 blocks for lettuce, 48 for cauliflower, 20 for tomatoes and 6 for cucumbers or strawberries. Generally from each potting mixture more plates were filled. The blocks of each plate were placed on different places on the plant bed. In principle the numbers of plates filled with blocks gave the number of replicates of the trials.

2.2 Description of the materials used

These materials can be subdivided into basic materials, organic manures, fertilizers and other chemicals.

The basic materials are peat moss, black peat, frozen black peat ("tuinturf"), river sand, dune sand, silver sand, clay and loam.

The *black peat* always came from the same site at Liesel in the municipality of Deurne (N-Br.). A description of the profile is given in Figure 1. The sphagnum peat naturally present was excavated for peat moss manufacture at the turn of the century.

In order to excavate the black peat the vegetation and part of the present upper layer were removed. For excavation a dragline was used and was dragged until the lake bottom deposit. The peat is decomposed with exception of the young sphagnum peat. According to VON POST the degree of decomposition is 7 to 8. On delivery the

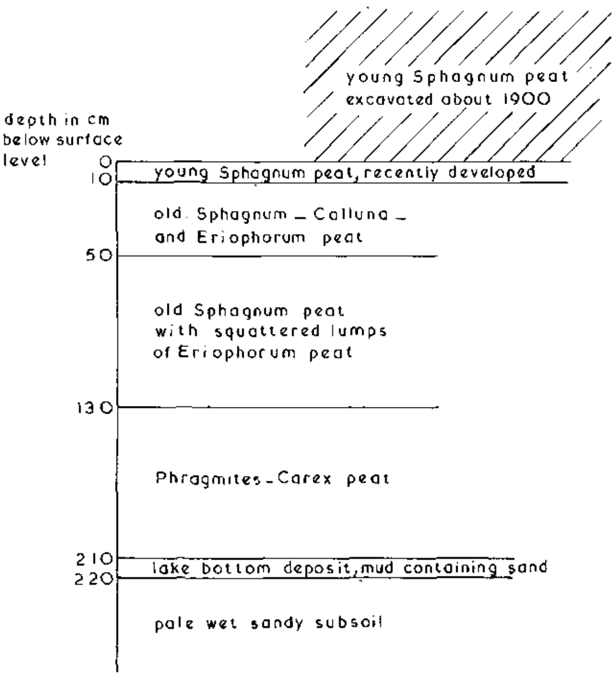


Fig. 1 Profile of the black peat site

Table 1. Analysis of black peat and peat moss

Analysis by the Laboratory for Soil and Plant Testing, Oosterbeek (figures based on dry weight)			Analysis by the Government Agricultural Experiment Station, Maastricht (figures are based on fresh weight)		
	black peat	peat moss		black peat	peat moss
pH-water	3.9	4.1	pH (in water)	4.1	4.4
pH-KCL	3.0	3.2	total nitrogen (%)	0.20	0.55
organic matter (%)	46.6	95.9	phosphoric acid (P_2O_5), soluble in mineral acid (%)	0.05	0
fraction smaller than 16 μ (%)	7	–	potash (K_2O), soluble in water (%)	0	0
coarse sand > 105 μ (%)	16	–	calcium oxide (CaO), soluble in mineral acid (%)	0.1	0.2
total sand (%)	46	–	carbon dioxide (CO_2) (%)	0	0
P-AL, mg P_2O_5 per 100 g	19	11	magnesium (MgO), soluble in mineral acid (%)	0.05	0.15
K-HCL, mg K_2O per 100 g	19	24	chlorine (Cl) as chloride (%)	0	0
Mg-NaCl, mg MgO per kg	658	–	salts, soluble in water (%)	0.07	0.07
total N (%)	0.56	0.91	loss-on-ignition (minus carbon dioxide and moisture) (%)	13,3	30,3
NaCl, mg per 100 g	3	0	moisture (140 °C) (%)	68,9	68,8
residue-on-ignition of a water extract (%)	0.09	–			
Fe_2O_3-HCL (%)	0.23	0.18			
Cu, mg per kg	1.5	1.5			

black peat was already somewhat mixed. For the different series mostly newly delivered black peat was used so that there may be differences in quality among the black peat used in different series. Characterization by VAN DIJK (in preparation) of the black peat as potting mixture can be found in publications of ROORDA VAN EYSINGA en MARTENS (1962, 1963). Some chemical information about the black peat is given in table 1. In order to measure the black peat in parts by volume a wheelbarrow with a capacity of 100 l or wooden cases with a capacity of 25 or 40 l were used. These were loosely filled with a fork. The fresh black peat had a moisture content of 75–80% by weight. The fresh weight, depending on the moisture content is 600 to 700 kg per m^3 with a dry weight of about 125 kg per m^3.

Peat moss of two proveniences was used in some series. In this case the peat moss is designated "Zwolle" or "Peel". Characterization by VAN DIJK may be found in the publications already mentioned. When the provenience is not indicated it may be taken as having the provenience "Zwolle". The visual appearance of this peat was that it consisted only of undecomposed sphagnum peat. Peat moss of the origin "Peel" is a type of sphagnum peat which is a little more decomposed. The peat moss was always delivered in bales. The peat moss bales were crushed by a high speed mill, 3 bales gave 1 m^3 of loose peat moss. To obtain the required amount of peat moss the measuring was done by using $^1/_2$, $^2/_3$ or 1 bale etc.

Depending on the moisture content, one bale of peat moss having a volume of 0.21 m^3, weighs 50 to 55 kg, the moisture content being 40 to 60% by weight. The dry weight of 1 m^3 loose peat moss is about 80 to 100 kg. A chemical analysis of the peat moss ("Zwolle") is given in table 1. Peat moss "Peel" was not analysed. Probably this origin of peat moss had a lower pH. The peat moss "Peel" used in series W had a pH-water 3.2 or pH-KCl 2.5.

Frozen black peat was also delivered in bales. Lumps of previously frozen black peat were crushed and then compressed into bales. For further details see EGBERTS en VAN DER KLOES (1960). Characterization by VAN DIJK can be found in the publications of ROORDA VAN EYSINGA en MARTENS (1962, 1963).

The samples for analysis mentioned in table 1 are taken from the deliveries used for series B. The black peat received for this series was probably polluted with about 2 to 5 vol % sand. From the analysis of table 1 it follows that the amount of nutrients in black peat and peat moss is very low, only the magnesium content possibly having some importance.

Three types of sand were used in this investigation, namely river sand, dune sand and silver sand. The dune and silver sand were only used for mixing with potting mixtures. The river sand is also used for filling the planting hole of the soil blocks.

The *river sand* came from a pit in the high terrace, an old deposit of the rivers Rhine and Meuse, near Venlo. The river sand is free of chalk, for further details see table 2. The dry weight of the sand is about 1400 kg per m^3.

The *dune sand* came from a pit in the dune sand area near Grubbenvorst, a village in the neighbourhood of Venlo. It was taken from the subsoil. The dry weight was about 1 350 kg per m^3. Further details in table 2.

The *silver sand* came from a pit near Heerlen in the south of Limburg. All the silver sand, unlike the other types of sand, was delivered in one load.

The *clay* came from a deserted pit at a brick-kiln in Flanders, Belgium, some kilometres south of the frontier with Zealand-Flanders. All the clay used in the different series was delivered at one time. The moisture content of the clay was about 20% by weight. The dry weight of the clay was 700 kg per m^3. For analysis see table 2.

The *loam* came from a deep pit belonging to Messrs. Russel-Tiglia, Tegelen, a village in the neighbourhood of Venlo. All the loam used was of the same provenience. The moisture content was about 20% by weight. The dry weight was 1000 kg per m^3. For analysis see table 2. According to the system used in the USA this type of soil is termed as silty clay.

The manures used in one or more series were: farmyard manure from various sources; cocoa organic lime also from various sources; town refuse compost of the DANO-plant of the municipality of Venlo and dried blood with about 13% total nitrogen.

Table 2. Soil analysis of river sand, dune sand, silver sand, clay and loam by the Laboratory for Soil and Plant Testing, Oosterbeek (figures based on dry weight)

	river sand	dune sand	silver sand	clay	loam
pH-water	5.6	–	–	6.2	8.0
pH-KCl	4.4	4.3	6.1	5.6	7.4
$CaCO_3$ (%)	0.1	–	–	0.3	8.0
organic matter (%)	0.5	0.6	0.3	4.8	1.2
$< 2\ \mu$ in % of mineral part	0.5	0	0	56	22
2–4 μ	0	0	0	7	8
4–8 μ	0.5	0	0	8	12
8–16 μ	0.3	0	0	8	15
16–25 μ	1	0.2	0.2	4	12
25–35 μ	0	1	0.1	3	9
35–50 μ	0.3	4	0.1	3.5	8
50–75 μ	0.5	8	0.2	7	4.5
75–105 μ	1	17	0.2	1	2
105–150 μ	2.5	35	15	0.3	1
150–210 μ	6	22	56	0.3	0.5
210–300 μ	13	9	25	0.4	0.5
300–420 μ	26	2	2.5	0.4	0.5
420–600 μ	20	1	0.4	0.3	1.5
600–850 μ	22	0.4	0.1	0.5	1.5
850–1200 μ	3.5	0	0	0.3	0.3
1200–1700 μ	2	0	0	0.2	0.4
P-getal, mg P_2O_5 per 100 g	0.3	–	–	0.3	0.3
P-AL, mg P_2O_5 per 100 g	3			23	7
K-HCl, mg K_2O per 100 g	4			58	14
Mg-NaCl, mg MgO per 1000 g	33			951	235
total N (%)	0.00			0.09	0.05
Fe_2O_3-HCl (%)	0.18			2.85	3.11
Cu, mg per kg	0.5			4	5

Cocoa organic lime, trade name Organo, is a waste material from the manufacture of theobromine from cocoa shells by the application of lime. (DIJK, 1963) Although more than one source was used a typical analysis of one sample is given in table 3.

Some figures of the analysis of town-refuse compost are also given in table 3.

The following, less well-known fertilizers are used:

Kencica, is the trade name for a blast-furnace slag of a cement factory, mostly consisting of calcium and potassium silicates, carbonates and sulphates. Kencica is manufactured by ENCI at Maastricht. Kencica has approximately 5% K_2O and has a neutralizing value of approximately 45% CaO. It is traded under a guaranteed standard of fineness. Next to potassium and calcium the borium content (0,005% B ?) may be of some importance.

Copper slag is the pulverised product of copper smelting-works. The trade name

Table 3. Analysis of cocoa organic lime and town refuse compost used in series B and C, by the Government Agricultural Experiment Station, Maastricht (figures based on fresh weight)

	cocoa organic lime	town refuse compost
pH (in water)	8.1	7.2
total nitrogen (%)	1.20	0.35
phosphoric acid (P_2O_5), soluble in mineral acid (%)	0.75	0.35
potash (K_2O), soluble in water (%)	0.10	0.05
calcium oxide (CaO), soluble in mineral acid (%)	8.7	3.0
carbon dioxide (CO_2) (%)	4.3	1.3
magnesium (MgO), soluble in mineral acid (%)	0.6	0.25
chlorine (Cl), as chloride (%)	–	0.1
salts, soluble in water (%)	0.4	1.5
loss-on-ignition (minus carbon dioxide and moisture) (%)	23,8	22.6
moisture (140 °C) (%)	59.6	32.5

Semo is used. This contains more than 1% copper, furthermore lead, zinc and cobalt.

Crescal is a compound fertilizer with 14% N, 10% P_2O_5 and 14% K_2O, of Chemische Werke Albert at Wiesbaden-Biebrich in Western Germany. It contains nitrogen in the form of ammonium, nitrate and urea. As well as N, P and K it contains 6% $MgSO_4$ (1% MgO), 0.5% $MnSO_4$ (0.15% Mn), 0.40% borax (0.05% B) and 0.40% $CuSO_4$ (0.05% Cu). Crescal was sold in crystalline form at the time.

Poly-Crescal comes from the same factory. The composition is about the same as Crescal, but phosphate is present as in the form of polyphosphate. The content of minor elements is 2.5% $MgSO_4$ (0.5% MgO), 1% $MnSO_4$ (0.35% Mn), 0.5% $CuSO_4$ (0.12% Cu); 0.77% borax (0.09% B) and 0.1% $ZnSO_4$ (0.02% Zn). Poly-Crescal is sold in crystalline form.

Floranid is a slow-acting nitrogen fertilizer on crotonilideendiurea base. It contains 28% nitrogen, one tenth being nitrate. Floranid is manufactured by BASF at Ludwigshafen on the Rhine (Western Germany). It is sold in granulated form.

The other chemicals included growth stimulators and insecticides.

The growth stimulators used were: α-naphtoic acid, 1-hydroxynaphtoicacid and 2-methoxybenzonitril. The latter was kindly supplied by N.V. Philips-Duphar, Weesp.

The insecticides used were aldrin dust 25% and heptachlor emulsion 25%.

3 Results

3.1 Relationship between plant size and yield

The quality of a potting mixture is evaluated by the growers from the growth of the plants pricked out in this potting mixture. When investigating potting mixtures the question arises whether it is sufficient to evaluate the plants visually at planting out stage. Other possibilities are determination of the plant weight at planting out time or determination either of the total yield or of the yield over a fixed time. Determination of plant weight and even more so the visual evaluation of plant size at planting-out time makes it easier and quicker to estimate the value of a potting mixture than in the case of recording of plant yield. For this reason the relationship between visual evaluation of plant size and of yield was estimated and also, in some cases, between fresh plant weight at planting out time and yield. This is done in some trials with lettuce and tomatoes and in only one trial with cucumbers and with cauliflowers. A review is given in table 4. In addition to some items on the number of potting mixtures and the number of replicates in table 4 there is also information about the correlation coefficients, the regression coefficients, the maximum and minimum values for visual evaluation (in some cases also for the fresh weight of the plants) and the maximum and minimum yields. It will be seen that in some cases two values were given for the correlation and regression coefficients. This is because the figures were based on the average results per replicate, per treatment, or in some cases on some other methods. The maximum and minimum values for visual evaluation and also for fresh weight and yield given in table 4 are calculated as treatment means.

Usually the plant size was visually evaluated by 5 persons, in a scale from 1 to 10, 1 being very small and 10 very large. The final figure was obtained by averaging the figures of the individual persons. The plant size was evaluated on various occasions, in one or two cases even shortly after planting out. The latest results were always used for calculating the coefficients. The fresh weight of the young plants was estimated by weighing the aerial parts of cut plants. The yield of lettuce is given as mean head weight in grams, the yield of tomatoes and cucumbers by decagrams per plant, for comparison of cucumber the number of fruits is also given. For cauliflower the yield is expressed as a percentage of heads of a minimum size (A-heads having a diameter taken over the head of more than 27 cm). In all the series, apart from series K, only the potting mixtures were varied whereas the cultivation measurements were always as equal as possible.

From the results of the two series (E and K) in which both visual evaluation and

Table 4. Relationship between visual evaluation (1 = very small, 10 = very large) or the plant weight in decigrams of young plants at planting-out time and the final yield (for lettuce the mean head weight in grams, for tomatoes and cucumbers the fruits in decagrams per plant and for cauliflower the percentage of A-heads)

Crop	Series	Number of mixtures	Number of replicates	Correlation coefficient for yield and		Regression coefficient for yield and	
				visual evaluation	plant weight	visual evaluation	plant weight
LETTUCE	A	12	(2)	0.48		5.4	
	B	56	3	0.40**–0.47**		6.3– 6.0	
	E	42	4	0.52**–0.61**	0.42**–0.44**	11.0–12.1	8.3–8.0
	G	59	4	0.28* –0.44**		4.6– 5.3	
		60	4	0.59**–0.72**		11.7–12.8	
	K	81	2	0.74**	0.63**	13.4	3.4
	S	21	6	0.67		11.4	
	V	24	7	0.58**		20	
		average				*11*	
TOMATOES	A	12	(4)	0.91**		10.2	
	C	42	2	0.64**–0.80**		16.2	
		42	2	0.26* –0.31*		9.8	
	G	59	3	0.36**		6.3	
		60	3	0.62**		10.3	
		average				*10*	
CUCUMBERS	O	12	3	0.68**		20.2	
CAULIFLOWER	O	30	3	0.65**		9.0	

* Significant at P = 0.05 level
** Significant at P = 0.01 level

estimation of fresh weight were made use of, it appears that visual evaluation gives a better correlation with yield than fresh weight does. The fact that visual evaluation gives a better correlation is due at least partly to the fact that only a small number of plants are available for the determination of plant weight as cut plants cannot, of course, be planted out. Since visual evaluation requires less labour, determination of fresh weight was only done in two series.

From the calculated correlation coefficients it follows that the size of the plants at planting-out time has an influence on their yield. The fact that the correlation coefficients are not higher is partly due to uncontrollable factors e.g. the influence of the site of the crop. The fact that the correlation coefficient for the early part of the yield is higher than for the total yield is also partly caused by the influence of the site of the crop, this influence increasing the longer the plants grow on this site. The correlation

Maximum and minimum (treatment means) for visual evaluation	for plant weight in dg per plant	Maximum and minimum for yield (treatment means)	Remarks
4–7		162–204	preliminary trial
3.6–7.6		152–200	
2.7–6.9	2.5–5.6	74–204	late lettuce
4.0–7.7		136–172	one potting mixture giving extremely poor results was omitted
2.5–7.7		41–172	the above-mentioned mixture included
1.8–8.6	1.6–19.8	92–241	variations in plant size entirely due to the date of pricking out
5.9–7.1		140–160	late lettuce
7.2–7.9		186–211	
3–9		207–281	preliminary trial
3.3–7.8		31–184	yield after 10 pickings
3.3–7.8		205–415	total yield
4.0–6.9		126–173	one potting mixture giving extremely poor results was omitted, 14 pickings
1.8–6.9		85–173	the above-mentioned mixture included, 14 pickings
4.7–7.8		320–424	earliest yield, 8 pickings
		(6.0–7.9)	(fruits per plant)
5.4–7.6		28–72	percentage of A-heads (diameter more than 27 cm measured over the head).

coefficients are also influenced by the differences in size between plants of the group. This is clearly shown by the correlation coefficients of the series G with lettuce and tomatoes. In this series there was a section of very poor plants. The correlation coefficient calculated including this group is higher than that excluding this group.

The influence of the plant size on production is likely to be a matter of earliness. This was not quite clearly proved for lettuce as all the lettuce was always harvested at one time. With some reserve it may be assumed that light-weight lettuce, grown from small plants, would have become heavier at a later date, so that the differences in head weight and consequently the correlation between plant size and yield would be smaller.

With tomatoes and cucumbers the effect on earliness was clearly shown in some cases. In Figure 2 the summarized yields of two groups both of bad and of good plants from series C are plotted. This figure shows that at the beginning of August after picking 10 times, the good plants yielded about twice as much as the poor ones. Afterwards the increase in yield of all the plants was about the same, so that the absolute difference in yield remains the same but the relative difference becomes smaller. The influence of the site of cropping becoming more pronounced, it is better for the estimation of the correlation between plant size and yield, to take not the total yield but the earlier part of the yield. This was therefore done in later series with tomatoes and cucumbers.

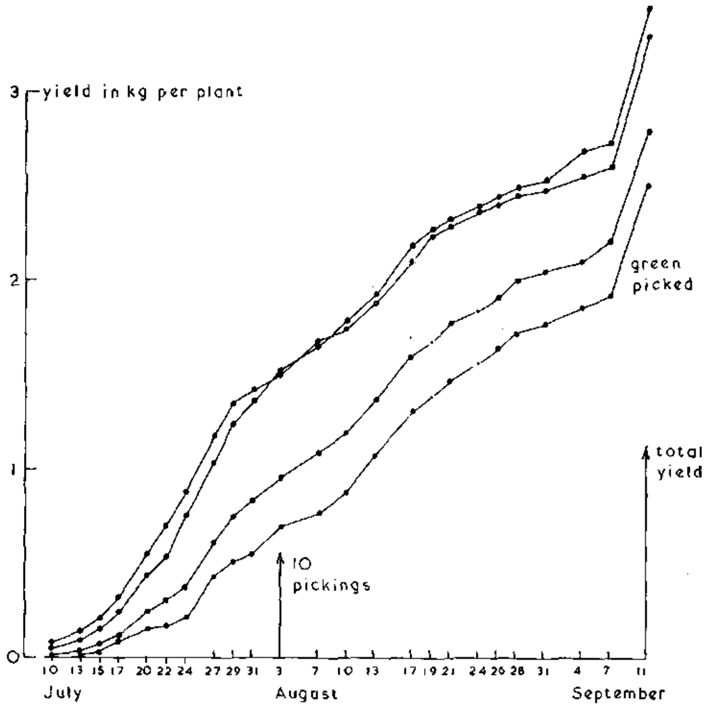


Fig. 2 The summarized yield of tomatoes of the two best and the two worst groups of plants (series C)

Systematic factors were sought that may have a disturbing influence on the correlation between plant size and yield. Some indications that the above factors may exist were shown in series U. In this series potting mixtures with different ratios of black peat and peat moss, some of which included increasing applications of silver sand were compared (for full details see Appendix). Not only was the variance of analysis calculated but also the co-variance. The F- and P-values are given in table 5.

The items of table 5 show that the influence of black peat was not found by evaluating plant size but it was found in yield. The analysis of co-variance furthermore gives a pretty high F-value, being $P = 0.06$. These figures indicate that under some conditions there may be differences in yield although the young plants may all look alike, in other words: some of the qualities of the potting mixture will assume predominance at a later date. Such a case can be imagined, e.g. if there are two potting mixtures one of them having a greater moisture absorptivity. The plants growing in the latter mixture would then tend to be better after planting out than those in the former mixture.

In studying the physical conditions of potting mixtures, when small differences in plant size occur it is not sufficient to measure or evaluate such differences, but instead the yield should be estimated.

Table 5. Some F- and P-values from the analysis of variance and co-variance of the figures for plant size and for yield of lettuce from series U

Factor	Degrees of freedom	Analysis of variance of figures for visual judgement		Analysis of variances of mean head weights		Analysis of co-variance of mean head weights	
		F	P	F	P	F	P
black peat	5	1.17	> 0.20	2.20(+)	0.06	1.67	> 0.20
black peat linear effect	1	1.30	> 0.20	3.81(+)	0.05_5	2.59	0.11
black peat quadratic effect	1	1.78	> 0.20	5.34(+)	0.02_5	3.65(+)	0.06

Since the plant size influences the yield, the question that arises is: – How great is this influence? To find an answer to this question the regression coefficients for the relation yield-plant size were calculated. For lettuce and tomatoes an average regression coefficient was roughly estimated. For tomatoes this average regression coefficient is about 10. This value, although not exact, means that a difference of 1 point in evaluation would give a difference in yield of 100 grams per plant. For lettuce more coefficients are available. Furthermore the figures for evaluation of lettuce of the various series can be compared. The level between the series will, of course, differ and the same is true of the yields. The actual meaning of 1 point of difference in evaluation regarding the difference in yield was sought in various series (see Figure 3).

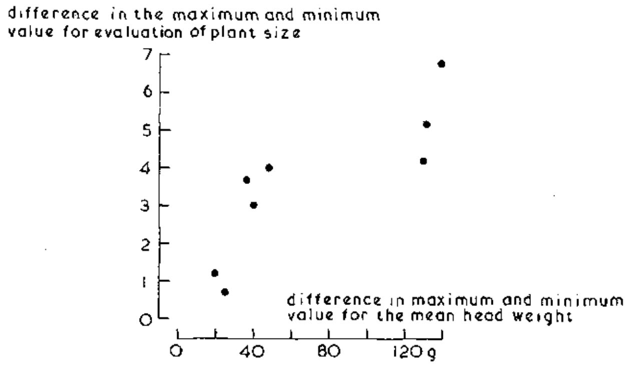


Fig. 3 Relationship between the difference of the maximum and minimum value for visually evaluated plant size (treatment means) and the difference in maximum and minimum value for mean head weight of lettuce (treatment means)

In this figure the differences between the lowest and highest figures for evaluation (treatment means) are plotted against the differences between the lowest and the highest mean head weight (treatment mean). The relation in Figure 3 is a curve. This is due to the fact that persons are inclined to compress the scale of plant size when measuring plants of a greater size range. This becomes clear in comparing the figures for evaluation and plant weights in series E and K (see table 4). In series E the maximum and minimum figures for judgement are about the same as for plant weight, in series K the figure for the maximum plant weight is about twice the maximum for evaluation, the minimum figures being about the same. It should also be mentioned that the relationship between plant size (weighed or evaluated) and yield is not quite rectilinear, see Figure 4.

Excluding these imperfections, it can be stated that a difference of 1 point in visual evaluation equals a difference of about 10 grams in mean head weight. Unfortunately it is difficult to indicate exactly what is meant by 1 point in evaluation, but roughly estimated it may be said to be 0,1 gram of fresh plant weight.

The conclusion that the differences in plant size are of influence on yield, is contrary to the opinion expressed by LAWRENCE (1948) who writes, *loc.cit.*: 'Neither you nor I can tell how good (or bad) our plants are by having a look at them'. Among growers it is generally held that for lettuce small, robust plants are probably the best and for tomatoes that bad plants in some cases gave extremely good production. Such information as the latter is of course impossible to verify.

With lettuce we believe that when night frost occurs shrivelling will be worse for the large plants than for smaller ones and consequently differences in yield according to plant size will be less pronounced. Of course this will not be the case in heated houses. Even in unheated houses larger plants, if hardened well, will give a higher, or perhaps rather earlier yield than smaller plants. We are of the opinion that the importance of good plants and especially the importance of plant size is largely underestimated in practice.

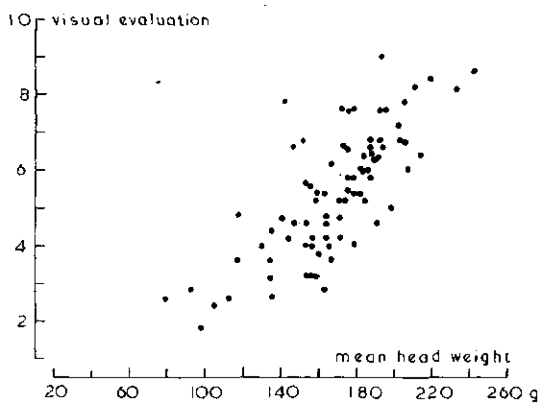


Fig. 4 Relationship between visually evaluated plant size (1 = very small, 10 = very large) and the yeild of lettuce (series K)

3.2 Optimal physical conditions of a potting mixture based on black peat and peat moss

With series B and C, with lettuce and tomatoes respectively, systematic research on the optimal physical conditions had been started. In these series the following materials were used:

a. black peat or peat moss
b. sand
c. clay or loam

A characteristic of these materials is given in 2.2.

The pF-curves of the soil blocks of series B was determined on a fairly extensive scale. Generally speaking the total pore content, being between 83.2% (4 parts peat moss, 1 part clay) and 53.7% (4 parts peat moss, 4 parts loam and 4 parts sand), decreased by the addition of clay, loam or sand.

The regression of the figures for plant size was calculated on the values for pH-KCl, vol % available water (between pF 0.4 to 2.0) and vol % air (total pore content minus vol % water at pF 0.4). When the mean averages of the two other factors are taken, the net regression formula for the third factor will be:

for pH−KCl	$y = -0.824$ (pH−KCl) $+ 47.85$ (standard error of coefficient of regression $= 0.036$)
for vol % water	$y = +0.133$ (vol % moisture) $+ 35.89$ (standard error of coefficient of regression $= 0.038$)
for vol % air	$y = -0.014$ (vol % air) $+ 42.73$ (standard error of coefficient of regression $= 0.087$).

The above formulae show that a higher pH−KCl (ranging from 5.0 to 8.0) is unfavourable, that a higher water content (ranging from 35 to 61 vol %) is favourable and that the air volume (ranging from 2 to 16 vol %) has no influence. It should be noted that the pH is obviously influenced by the application of the calcareous clay and loam and that the water content correlates with the quantity of peat added to the potting mixture.

At the time the calculations had been started, it was thought that in soil blocks, with a height of 5 cm the pF would be about 0.4. For this reason water content at this pF-value was taken into account. Afterwards it was found that pF is about 1.5 and upwards in soil blocks. The regression formulae were not estimated again because the water content at both pF-values is correlated.

In series C with tomatoes the addition of sand was unfavourable and the addition of clay or loam was even unfavourable to an almost negative or small extent. In the series B and C attention was paid to the possibility of making soil blocks from these potting mixtures and also to the ease of handling such blocks. Mixtures with a high percentage of clay or loam especially in the case of black peat were difficult to press, these mixtures being too sticky. Soil blocks containing a high percentage of peat moss were too brittle whether or not sand was added.

As a logical conclusion to these findings an attempt was first made to find a potting mixture which would be easy to press into soil blocks and handle. As there seemed to be no point in adding clay, loam or sand, because black peat is a sticky material which gives robust soil blocks and peat moss is a spongy material, trials with mixtures of black peat and peat moss together were then started.

In series D black peat alone, peat moss alone and 4 combinations of the two were mixed. With these mixtures the ease of pressing them out and the brittleness of the blocks were studied. The diameter of the blocks were also measured. Some results are given in table 6.

Table 6. Ease of pressing out potting mixtures based on black peat and peat moss and the diameter of blocks from these mixtures

	Black peat:peat moss (parts by volume)					
	100:0	80:20	60:40	40:60	20:80	0:100
ease of pressing (10 = excellent; 1 = poor)	6.4	6.4	6.8	6.8	7.0	6.4
diameter of the block in cm	4.9	5.1	5.2	5.4	5.5	5.7

The diameter is determined because a larger diameter indicates a higher air volume. Furthermore it was found that blocks with 60 or more parts by volume of peat moss were too brittle. Since, as is shown by the figures in table 6, mixtures with a high content of black peat are not so easy to press and the air volume may become too low, the mixture of equal parts by volume of black peat and peat moss was thought to be most promising. This mixture seemed to be so good that a number of trials were started to estimate optimal chemical conditions (see under 3.3). With later series the physical condition (i.e. the black peat – peat moss ratio) were again studied by cultivating various crops.

Frozen black peat "tuinturf". In series D not only black peat – peat moss mixtures were compared but also mixtures of frozen black peat with peat moss with the addition of CMC (carboxyl methyl chlorid), according to EGBERTS en VAN DER KLOES (1960). From 1/2 to 4% by weight CMC was added and this was calculated on the dry weight of the peat. The differences between these mixtures were slight, the mixture of 80 vol % frozen black peat and 20 vol % peat moss and 2% by weight CMC perhaps being the best. Mixtures of fresh black peat and peat moss, however, were more promising.

A mixture of 80 vol % frozen black peat and 20 vol % peat moss to which was added CMC, 10 vol % farmyard manure and fertilizers was tested with lettuce in series E. This was a failure, which fact must be ascribed to a too low water capacity with high pore space of this mixture (see also Fig. 5) under extremely dry weather conditions. In following series blocks pressed out of peat moss or of frozen black peat to which only fertilizers were added, gave reasonable results.

Plate V. The giant Flujas going in a procession through the city of Venlo

Table 7. Influence of the ratio of black peat-peat moss (or black peat-frozen black peat "tuinturf") on the growth of crops (for visual evaluation of size 1 = very small, 10 = very large)

Crop	Series	Parameter	Fresh black peat:peat moss (parts by volume) 100:0	80:20	75:25	60:40	50:50	40:60	25:75	20:80	0:100
LETTUCE	G	visual evaluation	7.2	7.3		7.3		7.3			
		mean head weight in g	149	163		145		154			
	N	plant weight per plant in g	2.2	2.4		2.4		1.8		2.0	1.8
		plant weight per plant in g	1.8	2.0		1.9		1.9		1.7	1.4
		plant weight per plant in g	1.8	1.7		2.1		1.7		1.6	1.5
	Q	plant weight per plant in g	2.3	2.9		2.9		2.7		2.4	2.6
		plant weight per plant in g	2.0	3.0		2.7		2.5		2.8	2.9
		plant weight per plant in g	2.2	2.5		2.9		2.5		2.4	2.8
		plant weight per plant in g	2.2	2.3		2.5		2.4		2.6	1.9
		plant weight per plant in g	2.2	2.4		2.6		2.4		2.7	2.1
		plant weight per plant in g	1.9	2.5		2.2		2.2		2.5	2.2
		plant weight per plant in g	2.3	2.0		2.7		2.6		2.5	2.0
		plant weight per plant in g	2.1	2.2		2.3		2.3		2.4	2.1
		plant weight per plant in g	2.5	2.6		2.4		2.6		2.4	2.4
		plant weight per plant in g	2.2	2.2		1.9		2.3		2.4	2.0
		plant weight per plant in g	2.5			2.9		2.5			2.9
		plant weight per plant in g	2.4			2.7		2.4			3.0
	U	visual evaluation	7.5	7.5		7.5		7.6		7.6	7.5
		mean head weight in g	191	192		201		201		200	196
		visual evaluation	7.6	7.4		7.8		7.7		7.4	7.9
		mean head weight in g	194	191		211		204		196	209
TOMATOES	G	visual evaluation	6.5	5.9		6.3		5.0			
		yield after 14 pickings in kg per plant	1.44	1.28		1.41		1.42			
	N	plant weight in g	1.8	1.8		1.7		1.6		1.4	1.6
		plant weight in g	1.4	1.6		1.6		1.6		1.5	1.2
		plant weight in g	1.5	1.9		1.7		1.6		1.4	1.3
	U	plant weight in g	0.97	1.04		1.13		1.05		1.05	0.99
			0.76	0.82		0.88		0.85		0.86	0.79
CUCUMBERS	U	plant weight per plant in g	3.4	3.7		3.4		3.2		3.4	3.1
	W	plant weight in g per plant	9.5		11.7		11.5		11.8		11.1
		plant weight in g per plant	11.2		12.9		12.2		12.9		10.9

	Statistical evaluation P-value (ns = not significant)	
	lin.	quadr.
10 vol % farmyard manure added	ns	ns
	ns	ns
"Zwolle" peat moss } after correction to eliminated differences due to the variances of the cropping site	< 0.01	ns
"Peel" peat moss } after correction to eliminated differences due to the variances of the cropping site	ns	ns
frozen black peat } after correction to eliminated differences due to the variances of the cropping site	ns	0.09
"Zwolle" peat moss with wet raising conditions / "Zwolle" peat moss with dry raising conditions	ns	0.07
"Peel" peat moss with wet raising conditions / "Peel" peat moss with dry raising conditions	ns	0.05
frozen black peat with wet raising conditions / frozen black peat with dry raising conditions	ns	0.03
"Zwolle" peat moss with wet raising conditions / "Zwolle" peat moss with dry raising conditions } 10 vol % farmyard manure added	ns	0.03
"Peel" peat moss with wet raising conditions / "Peel" peat moss with dry raising conditions } 10 vol % farmyard manure added	ns	ns
frozen black peat with wet raising conditions / frozen black peat with dry raising conditions } 10 vol % farmyard manure added	ns	ns
means of the various sand applications	ns	ns
	0.06	0.03
sand excluded	ns	ns
	0.09	ns
10 vol % farmyard manure added	0.05	ns
	ns	ns
"Zwolle" peat moss } after correction to eliminated differences due to the variances of the cropping site	< 0.01	ns
"Peel" peat moss } after correction to eliminated differences due to the variances of the cropping site	< 0.01	0.01
frozen black peat } after correction to eliminated differences due to the variances of the cropping site	< 0.01	< 0.01
with wet raising conditions	ns	0.02
with dry raising conditions	ns	< 0.01
	0.02	ns
"Zwolle" peat moss means of the various sand applications	< 0.01	< 0.01
"Peel" peat moss	ns	0.03

The results with the growth of crops in those series in which the black peat - peat moss ratios were studied are summarized in table 7.

Table 7 shows that there is little difference in growth with various ratios of black peat and peat moss. Generally speaking equal parts by volume give the best results and the extreme ratios sometimes result in decreasing growth. Afterwards the choice of the 1 to 1 ratio appeared to be a good one. This 1 to 1 mixture is named "Flujas". This name denotes a potting mixture of equal parts by volume of black peat and loose peat moss, taking it that 1 m^3 loose peat moss equals 3 bales. Flujas is registered as a trade-mark for potting soil. Legend has it that the town of Venlo was founded by the giant Flujas and his wife Guntruud (Plate V).

It should be noted that the optimal chemical conditions (see 3.3) are estimated for the 1 to 1 mixture. Assuming an interaction to exist between chemical and physical conditions, it is possible that the extreme ratios decrease growth of the crop as a result of unfavourable chemical conditions. However, the quantity of nutrients in the peat blocks of the various mixtures is at least the same. In table 8 the dry weight of loose potting mixture and of blocks, and the number of blocks of 100 cm^3 that can be pressed out of 1 m^3 potting mixture is given. The figures in table 8 are taken from series G. Table 32 and figure 16 shows the number of peat blocks with various diameter that can be pressed out of 1 m^3 Flujas mixture. As the fertilizers are always applied to volume units, it becomes clear from the figures in table 8 that at least the quantity of nutrients in the soil blocks of each mixture is much the same.

Table 8. Estimation of the number of peat blocks of 100 cm^3 that can be pressed out of 1 m^3 potting mixture

Potting mixture	Dry weight of blocks of 100 cm^3 (in g)	Dry weight of 1 m^3 loose potting mixture (in kg)	Number of blocks to press out of 1 m^3 potting mixture
black peat	19.6	121.7	6210
Flujas	15.1	92.2	6105
peat moss	13.5	82.9	6150

Apart from cultivation trials with potting mixtures with different ratios of black peat and peat moss, the pF-determinations of these mixtures also indicate that the Flujas-mixture is more promising than the basic materials peat moss or black peat alone. Figure 5 shows the water content at pF 1.5 and pF 4.2 and the solid matter content of these mixtures. Water content was estimated at pF 1.5 because directly after the pressing of the peat blocks pF is usually 1.5. With various mixtures there are some differences in the pF-value directly after pressing, blocks of black peat having pF 0.5, blocks of peat moss having pF 1.6 to 1.8.

Figure 5 shows clearly that the available water content (pF 1.5–4.2) in blocks of the Flujas mixture is greater than in the blocks of the basic materials. Blocks of pure peat moss or frozen black peat also have a high air content at low pF-values, which is why there will soon be a water shortage with dry weather conditions. Actually the air content is greater because of the increase in volume of peat blocks after pressing due to the elasticity especially, which in the case of peat moss is very high. In Figure 5 the changes in the volume of peat blocks by elasticity are not taken into account: for this information see ROORDA VAN EYSINGA en MÄRTENS (1962, 1963).

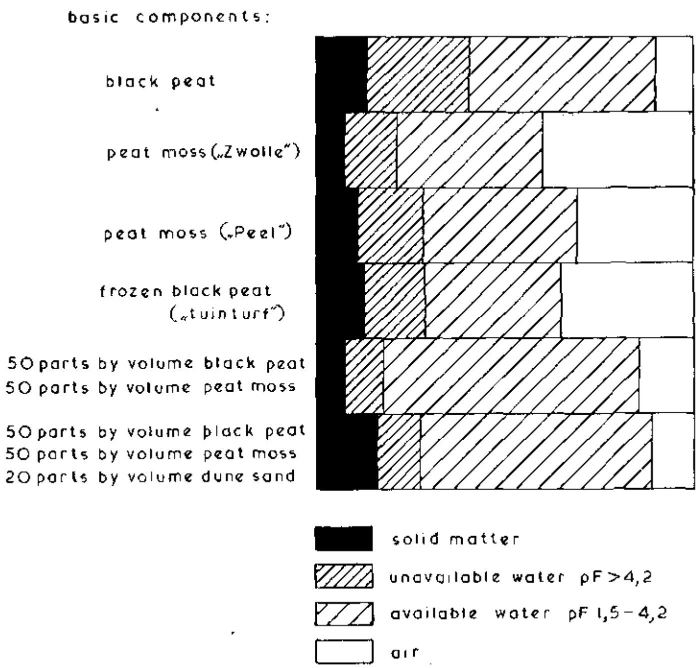


Fig. 5 Soil: water: air-relationship in some peaty potting mixtures

A weak point about the Flujas mixture might be the air volume at pF 1.5, which is only about 10 vol %. It should be noted that the air content increases immediately, when the blocks become even only slightly drier. According to BUNT (1961) an air capacity of 5 vol % is sufficient. Moreover with blocks air can penetrate more easily into the soil from all sides than with the clay pots used by BUNT. Even an unfavourable influence of low air capacities (ranging from 2 to 16 vol % at pF 0,4) was not found in the regression formulae estimated from figures from series B. Although an air capacity of 10 vol % and less is considered as undesirable for soils under natural conditions, there are no indications that this rule is also applicable to soil blocks.

The addition of sand to the Flujas-mixture was studied in series G and S. The addition of sand to mixtures with different ratios of black peat and peat moss was studied in series U and W. The results are summarized in table 9. The figures of series U and W in table 9 are averages of the black peat and peat moss ratios. As the interactions

Table 9. Influence on the growth of crops with the addition of sand to mixtures of black peat and peat moss (for visual evaluation of plant size 1 = very small, 10 = very large)

Crop	Series	Parameter	Parts by volume of sand: 0	7.5	10	15	20	30	Type of sand (for analysis see table 2)	Remarks	Statistical evaluation P-value (ns = not significant): linear	quadr.
LETTUCE	G	visual evaluation of plant size	6.7		7.3		7.6		river sand		0.01	ns
		mean head weight in g	155		156		152				ns	ns
		visual evaluation of plant size	7.3		7.1		7.6		dune sand		ns	ns
		mean head weight in g	156		168		164				ns	ns
		visual evaluation of plant size	7.1		7.7		7.1		silver sand		ns	0.05
		mean head weight in g	150		160		159				ns	0.04
	S	visual evaluation of plant size	6.6		6.5		6.6		dune sand	as an average of increasing	ns	ns
		mean head weight in g	154		153		153			applications of lime	ns	ns
	U	visual evaluation of plant size	7.6	7.5		7.6		7.5	silver sand	as an average of black peat-	0.07	ns
		mean head weight in g	201	199		193		196		peat moss ratios.	ns	ns
TOMATOES	G	visual evaluation of plant size	6.4		5.8		5.5		river sand		ns	ns
		yield after 14 pickings in kg per plant	1.49		1.44		1.48				ns	ns
		visual evaluation of plant size	6.1		6.2		5.7		dune sand		ns	ns
		yield after 14 pickings in kg per plant	1.47		1.39		1.53				0.04	ns
		visual evaluation of plant size	6.9		6.5		6.5		silver sand		ns	ns
		yield after 14 pickings in kg per plant	1.46		1.58		1.49					
	U	plant weight in g per plant	1.09	1.03		1.01		1.02	silver sand with wet raising conditions	as an average of black	ns	ns
		plant weight in g per plant	0.86	0.84		0.79		0.81	silver sand with dry raising conditions	peat-peat moss ratios	0.06	ns
CUCUMBERS	U	plant weight in g per plant	3.4	3.4		3.4		3.5	silver sand	as an average of black peat-peat moss ratios	ns	ns
	W	plant weight in g per plant	11.6			11.3		10.4	silver sand	as an average of black peat-peat moss ratios	< 0.01	0.01

between the increasing applications of sand and the ratios of black peat and peat moss in series U were significant, the figures for yield and plant size as treatment means are shown in table 11.

The results with the addition of sand are different in the various series. With the addition of 10 vol % sand in series G the growth of the lettuce plants was slightly but significantly better. The other series with lettuce or other crops gave rather negative results. The cause of these varying effects is not clear. A conclusion from series G was that silicate may have some influence. An experiment (series S) was therefore started in which dolomite lime with 20% MgO (Dolokal supra) and a mixture of dolomite lime and a potassium-calcium-silicate (Kencica) were compared, both combined with increasing applications of sand. In this experiment, performed in 6 replicates, no significant differences were found, except for the omission of lime. Dolomite lime gave a slightly better plant size and Kencica a slightly higher mean head weight (see table 10 and figure 12). No interaction between the type of lime and the amount of sand added was found and the addition of sand had no or at the utmost a negative influence.

Table 10. Influence of increasing applications of lime and/or dune sand to the Flujas-mixture on the visually evaluated size of lettuce plants (1 = very small, 10 = very large) (series S)

Lime applied per m^3	Dune sand in vol %			Mean
	0	10	20	
no lime	5.9	6.0	5.8	5.9
2 kg Dolokal supra	6.6	6.7	6.5	6.6
4 kg Dolokal supra	7.0	6.5	6.8	6.8
6 kg Dolokal supra	7.1	6.8	6.6	6.8
2 kg half Dolokal supra/half Kencica	6.4	6.4	6.7	6.5
4 kg half Dolokal supra/half Kencica	6.7	6.8	6.8	6.8
6 kg half Dolokal supra/half Kencica	6.5	6.5	6.9	6.6
mean	6.6	6.5	6.6	
total sum (n = 42)	277.8	273.4	276.4	

Statistical evaluation: omission of lime significant at $P < 0.01$, effect of sand not significant.

For series U the analysis of variance of the figures for visual evaluation shows a significant interaction between the addition of silver sand and the ratio of black peat and peat moss. This interaction was neither linear nor quadratic but of higher degree and is therefore of no importance (see table 11).

Although the interaction between sand application and black peat - peat moss ratio was not significant with the mean head weight, the picture is more clear than with the visual evaluations of plant size. It seems that with the application of sand the best mixture contains more peat moss. This coincides with what we expect, because pore space decreases by the addition of sand and increases by a higher peat moss percentage.

Table 11. Influence of the addition of sand to various ratios of black peat and peat moss on the visually evaluated plant size (1 = very small, 10 = very large) and in parentheses the mean head weight of lettuce in grams (series U)

Part by volume		Silver sand (parts by volume)			
black peat	peat moss	0	7.5	15	30
100	0	7.6 (194)	7.5 (186)	7.4 (190)	7.4 (194)
80	20	7.4 (191)	7.5 (194)	7.3 (186)	7.7 (198)
60	40	7.8 (211)	7.5 (201)	7.6 (196)	7.3 (195)
40	60	7.7 (204)	7.6 (205)	7.7 (199)	7.7 (194)
20	80	7.4 (196)	7.6 (201)	7.9 (198)	7.7 (204)
0	100	7.9 (209)	7.2 (195)	7.6 (188)	7.3 (192)

Statistical evaluation: *plant size*, no significant effects; *head weight*, sand linear negative effect at P = 0.07, peat ratios linear effect at P = 0.05, quadratic effect at P = 0.03; interaction not significant.

As the cultivation trials with sand application give varying results, other considerations are to be accounted however, for concerning the omission of sand, except in those cases were such addition proved to be favourable, since the application of sand has the disadvantage of increasing the weight of the potting mixture and hence of the blocks. The addition of 10 vol % sand to the Flujas mixture doubles its dry weight. When planting out, all plants have to be moved by hand, so that light-weight blocks will be highly appreciated by the growers. According to TEPE (1952) there is no point in adding sand to a potting mixture because the sand does not contribute to its nutrient content, but only serves to stop up pores. The latter is also illustrated in Figure 5. The stopping up of pores may be desirable under certain circumstances. According to the U.C. system (BAKER 1957) the addition of sand to peat moss is recommended for different purposes.

Apart from the light-weight blocks already referred to, a potting mixture of black peat and peat moss has other advantages. Black peat and peat moss are plentifully available, they are naturally free of pathogens and weeds and contain hardly any nutrients, so that the nutrient content can be adjusted to the exact requirements. The latter property was also considered to be a good one by EGBERTS en VAN DER KLOES (1960). A further discussion will be found in chapter 5.

3.3 Optimal chemical conditions of a potting mixture based on black peat and peat moss

3.3.1 Nutrients

Series B. The results with lettuce in series B, which series does not deal with the Flujas mixture, but with a mixture of black peat or peat moss plus sand plus clay or loam in 4 : 2 : 1 parts by volume, are now summarized.

The omission of mineral phosphate was disastrous, as no farmyard manure had been added to the potting mixture. When 10 vol % farmyard manure was added, the mineral phosphate showed no reaction with only one of the sources of farmyard manure. With the other source of farmyard manure the best plants were obtained with an application of 4 kg dicalcium phosphate per m^3. The mixtures of clay already having a pH-KCl of about 6.2 without lime, and those of the mixtures of loam of 6.9, the addition of lime was unfavourable. The influence of an application of 1 kg copper slag, was not clear (see table 20). The addition of 10 g sodium molybdate per m^3 to the mixtures of loam was more favourable than when no molybdate was added (see table 20). Three origins of cocoa organic lime were compared. One of these gave a complete crop failure, which was probably due to the fact that this sample was not sufficiently fermented.

The results of the other series concerning the variations in chemical condition of the Flujas mixture will be discussed in sections, relating to the addition of farmyard manure, the application of macro-elements, micro-elements and growth stimulators and insecticides.

Farmyard manure. It was first thought that farmyard manure had to be added. The results with various sources of farmyard manure were quite different. Later on it was found that with the application of fertilizers alone, results were obtained which were every bit as good as when farmyard was added. Consequently farmyard manure was increasively omitted.

The use of farmyard manure as a fraction of the potting mixture has both advantages and disadvantages. Some disadvantages are: the variation in quality of farmyard manure which causes differences in crop growth, farmyard manure may contain pathogens and is likely to contain weed seeds. Generally the effects of fertilizer application are less when farmyard manure is added. Studying the optimal chemical conditions becomes difficult as the nutrient supply of the farmyard manure is unknown. Some advantages are: the addition of farmyard manure to a peaty potting mixture by the growers is favourable because mistakes in fertilizer application will be less serious owing to slow release of nutrients from farmyard manure, black peat and peat moss having hardly any nutrient release. The latter is especially important for potting mixtures in which plants are grown for a long time.

The data of series G, in which four applications of nitrogen, phosphate and lime were studied in all combinations with fertilizers alone or with 10 vol % of farmyard manure from two sources, were extensively mathematically analyzed. In the case of the mean head weight of lettuce there was a significant interaction between phosphate and the various combinations (only fertilizers, farmyard manure I or farmyard manure II) to which it was applied. There was also an interaction with lime in the case of the visual evaluation of lettuce and of the yield of tomatoes, which was highly significant ($P \leqslant 0.01$). These interactions indicate that the effect of the fertilizers is apparent when farmyard manure is not applied.

Table 12. Influence of increasing applications of lime with 10 vol % farmyard manure from 2 sources on the visual evaluated size of lettuce plants (1 = very small, 10 = very large). In parentheses the pH-KCl of the potting mixtures

	kg dolomite lime per m³			
	0	1.5	3	6
farmyard manure I	5.5 (4.1)	5.5 (4.7)	6.2 (4.9)	6.6 (5.15)
farmyard manure II	6.5 (4.1)	5.4 (4.75)	5.8 (4.95)	5.7 (5.2)

Statistical evaluation: no significant effects.

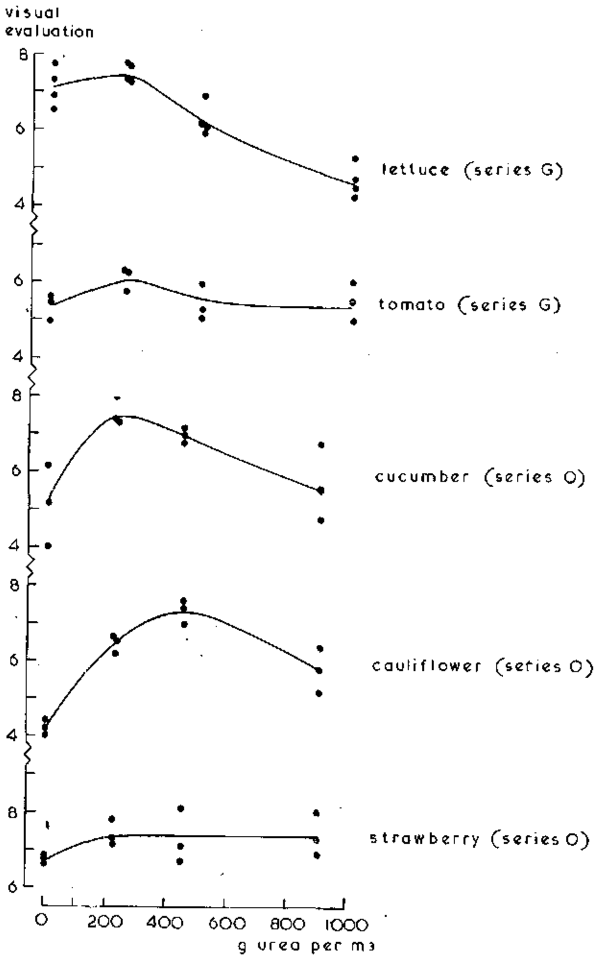
In series E contradictory results (differences were not, however, significant) were obtained with four applications of lime and two sources of farmyard manure, see table 12.

The estimate of the pH of the potting mixtures does not explain the differences in plant size. It should be noted that the pH of the mixture, with the application of farmyard manure and fertilizers – apart from lime –, is strikingly higher than that of a mixture of equal parts by volume of black peat and peat moss having a pH-KCl of about 3.1.

Nitrogen. The young plants reacted clearly to nitrogen application, especially when farmyard manure was not added to the potting mixture. Omission as well as heavy application of nitrogen decreased growth (see Fig. 6). This figure shows that the optimal application of urea is about 200 to 300 g per m^3 for most crops; only cauliflowers require as high a figure as 450 g. Strawberries also gave an exception as no optimum was found.

Strawberries were cultivated with the use of soil blocks in a preliminary trial (series P) in the 1960–1961 season. Strawberry runner plants were pricked out into blocks at the end of July and were afterwards placed on a plant bed in the open until the beginning of January. Nitrogen was leached out of the peat blocks during the extremely wet autumn and symptoms of nitrogen deficiency became visible. A top dressing of nitro-chalk improved the pale colour of the leaves. In this trial the base application of nitrogen to the potting mixture was 140 g N per m^3, given as Poly-Crescal. In order to study the possible methods of preventing the leaching of nitrogen, a trial (series AA) was carried out in the 1961–1962 season, in which applications of nitrogen as nitro-chalk (23 % N), as Floranid and as a mixture of both (fifty-fifty on N base) were compared. The plant size was visually evaluated one month after pricking out (see table 13). The weather in the autumn of 1961 was dry.

Because the differences became less, except for the treatment without nitrogen, plant size was not again evaluated. The growth of plants in blocks without nitrogen remained backward, although no leaf discoloration was observed. Table 13 shows that 150 g nitrogen per m^3 is sufficient under dry weather conditions. Nitrogen deficiency occurring under wet weather conditions should be controlled by top dressing.



Statistical evaluation; *lettuce:* negative linear effect significant at $P < 0.01$, quadratic at $P = 0.01$; *tomato:* no significant effects; *cucumber:* quadratic effect significant at $P < 0.01$; *cauliflower:* positive linear and quadratic effects significant at $P < 0.01$; *strawberry:* no significant effects

Fig. 6 Influence on some crops of the application of urea to the Flujas mixture on the visually evaluated plant size (1 = very small, 10 = very large)

Floranid, giving the best results on average, seems to be a promising fertilizer to apply to potting mixtures subject to leaching.

Various nitrogen fertilizers were compared, using lettuce and tomatoes in series H. The results of this visual evaluation are illustrated in Figure 7. As this figure shows, differences with lettuce are almost negative. With tomatoes, differences – due to the various fertilizers – appeared, but with later visual evaluation and with the estimation of plant weight (see table 14) these differences were neglectable.

As is shown in table 14, the optimal nitrogen application is about 100 to 200 g N

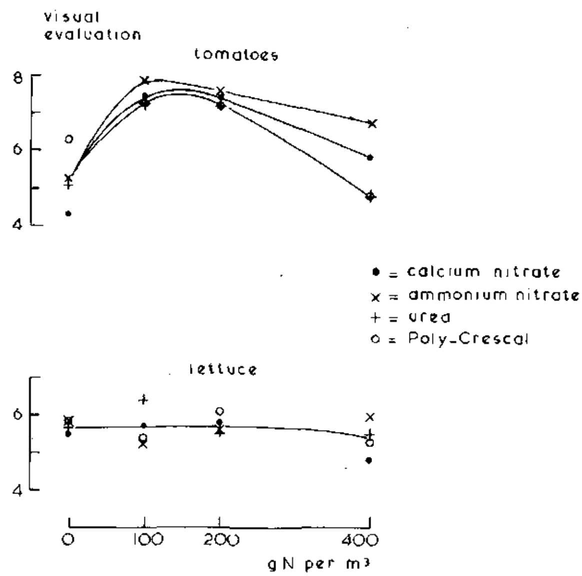
Table 13. Visually evaluated plant size (1 = very small, 10 = very large) of strawberries grown in the Flujas mixture with different nitrogen applications

Fertilizers applied	g N per m³				Mean (of rate 150–600 g)
	0	150	300	600	
nitro-chalk		6.0	5.6	5.2	5.6
nitro-chalk and Floranid (fifty-fifty on N-base)	5.7	6.4	5.8	5.9	6.0
Floranid		6.1	6.3	6.4	6.3

Statistical evaluation: Floranid, fifty-fifty mixture > nitro-chalk (rates 150–600) at P = 0.03, negative linear effect of nitro-chalk (rate 150–600) significant at P = 0.07.

per m³. It is not clear which is the best nitrogen fertilizer; a too heavy application is most dangerous with urea and Poly-Crescal.

The optimal nitrogen application was about the same for smaller and taller tomato plants; this was studied with two nitrogen fertilizers in series O. The decreasing rate of growth of the large plants, due to the nitrogen omission, was more pronounced than with the smaller plants (see Fig. 8).



Statistical evaluation: *tomato*, calcium nitrate and amm.nitrate positive linear effect significant at P = 0.05; Poly-Crescal negative linear effect significant at P < 0.01, urea at P = 0.06; all N-fertilizers quadratic effect significant at P < 0.01, *lettuce:* no significant effects

Fig 7 Influence of various nitrogen fertilizers applied to the Flujas mixture on the visually evaluated size (1 = very small, 10 = very large) of lettuce and tomato plants (series H)

Table 14. Influence of increasing applications of various nitrogen fertilizers to the Flujas mixture on the fresh weight in grams of tomato plants (series H)

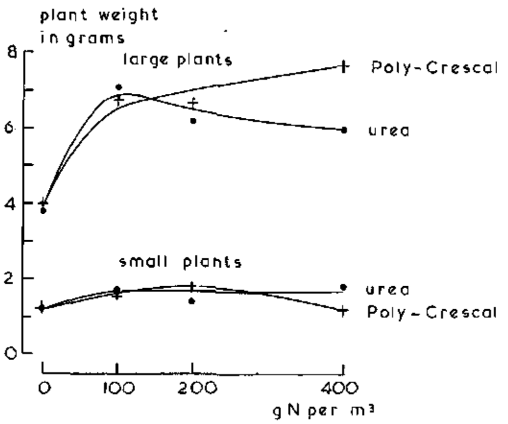
Fertilizers applied	g N per m³				mean of rate 100–400g N per m³
	0	100	200	400	
calcium nitrate	6.0	10.5	10.3	7.5	9.4
ammonium nitrate	7.7	11.6	10.8	9.8	10.8
urea	7.8	10.9	11.2	6.8	9.6
Poly-Crescal	8.7	11.8	10.0	5.9	9.2
mean	7.6	11.2	10.9	7.5	

Statistical evaluation: rates of nitrogen significant at $P < 0.01$; kind of fertilizer significant at $P = 0.05$; interaction rates × kind of fertilizer significant at $P = 0.03$, linear negative nitrogen component (rate 100–400) × kind of fertilizer significant at $P = 0.03$.

With lettuce were compared dried blood and urea, applied to the Flujas mixture with 10 vol % farmyard manure from two sources in series E. No clear differences were obtained, see table 15.

From these trials, too, the optimal nitrogen application for lettuce and tomatoes appears to be about 100 to 200 g N per m³. With heavy applications of urea to lettuce and tomatoes typical symptoms were observed in some cases and over a certain period. These symptoms were the curling down of the leaves.

As already mentioned, nitrogen was leached out of peat blocks in which strawber-



Statistical evaluation: *large plants;* kind of fertilizer no effects, positive linear N-effect significant at $P < 0.01$, quadratic at $P = 0.02$, nitrogen (rate 100–400) > no nitrogen at $P < 0.01$; *small plants:* interaction kind × rate of fertilizer significant at $P < 0.01$, urea linear effect, at $P = 0.02$; Poly-Crescal quadratic effect at $P = 0.02$, nitrogen (rate 100–400) > no nitrogen significant at $P < 0.01$

Fig. 8 Influence of nitrogen application to the Flujas mixture on the fresh weight of plants, some groups of which were large and others small at pricking out time

Table 15. Influence of application of urea or dried blood to the Flujas mixture with 10 vol % farmyard manure on the visual evaluation of lettuce plants (1 = very small, 10 = very large) and in parentheses the mean head weight in grams

Application	Urea (45 % N) g per m³			
	0	250	500	1000
farmyard manure I	4.8 (153)	4.8 (155)	5.5 (181)	5.2 (177)
farmyard manure II	5.7 (138)	6.5 (165)	6.4 (174)	5.8 (169)
	dried blood (13 % N) g per m³			
	0	1250	2500	5000
farmyard manure I	4.7 (166)	5.3 (185)	5.4 (172)	4.9 (169)
farmyard manure II	5.8 (166)	5.8 (170)	5.6 (156)	6.3 (167)

Statistical evaluation: *plant size:* kind and rate of nitrogen fertilizers no significant effects, differences between manures significant at $P < 0.01$, no significant interactions; *head weight:* kind of nitrogen fertilizer no significant effects; urea, linear positive effect at $P = 0.09$; blood, linear positive effect at $P = 0.08$; differences between manures not significant, no significant interactions.

ries were grown in the cultivation trial in 1961 and which were kept out of doors. In practice, in many cases nitrogen deficiency symptoms were found by raising plants in peat blocks in the extremely wet autumn of 1961. It was not certain that the nitrogen was leached out of the potting mixture. It might be fixed, and an experiment (series X) was started, to study this. For this series exactly similar potting mixtures were made on different dates. The mixtures were stored in plastic baskets out of doors in the spring of 1962. The weather was very wet. Samples from different layers were taken after some time. The samples were analysed for moisture content (A-figure being g moisture per 100 g dried soil) and for nitrate and ammonium in MORGAN's extract. The samples being very small, the extraction ratio used was 1:5 instead of the normal 1:2.5 (SCHUFFELEN e.a. 1961). The figures in table 16 have already been doubled in order to compare them with other normally found figures. The total nitrogen content in the extract is calculated from nitrate content and ammonium content together.

The older mixture contains less nitrogen than the younger one. Nitrogen content increases with the depth of the heap of the potting mixture. From this experiment it seems very probable that nitrogen may leach rather quickly out of a potting mixture based on black peat and peat moss.

SOUKUP (1962), using percolation tubes with a lenth of 15 cm and filled e.g. with peat moss, studied the leaching of ammonium nitrate by analysing ammonium and nitrate in eluates. From the items of SOUKUP it was calculated that with 174 mm rainfall 60% of the ammonium and 90% of the nitrate was leached out from peat moss and, with 226 mm rainfall, 65% of the ammonium and 95% of the nitrate. According to the analysis of a sample of Flujas mixture from series Q, the initial content must have been 85 ppm NH_4 and 31 ppm NO_3 in MORGAN's extract. 91% of the ammonium and 9% of the nitrate is leached out of the upper 15 cm layer of the potting mixture by 174 mm rainfall, and 93% and 35% by 226 mm. Ammonium being adsorbed, it

Table 16. Moisture content and nitrogen content of Flujas mixtures stored out-of-doors and rainfall in the period between manufacturing date and sampling date, viz. 11th May

Date of manufacturing	Rainfall in mm	Depth of sampling in cm	A-figure	ppm in MORGAN's extract NO_3	NH_4	$N (NO_3 + NH_4)$
10th Febr.	226	0– 5	247	17	2	5
		5–10	240	19	6	9
		10–15	274	23	10	13
		15–20	357	25	16	18
		20–25	388	33	19	22
15th March	174	0– 5	226	27	3	8
		5–10	321	37	9	15
		10–15	330	40	12	18
		15–20	354	42	14	20
		20–25	416	52	27.5	33

leaches more slowly than nitrate, as is also shown by the figures of SOUKUP, so that it must be concluded that in the heaps of potting mixture part of the ammonium is converted into nitrate. Calculating total nitrogen from ammonium and nitrate content gives a leaching of 75 and 80% according to SOUKUP after 174 and 226 mm rainfall respectively and from the upper 15 cm layer of potting mixture a leaching of 81 and 88% respectively. Despite the differences in methods of both experiments the similarity is striking and we can only conclude that nitrogen leaches easily and quickly out of the Flujas mixture.

Phosphate. The omission of phosphate will sometimes give a crop failure. The effect of phosphate on plant growth is less clear when farmyard manure is added to the potting mixture (see table 17).

Except for some cases in which a compound fertilizer was used, phosphate was always applied as dicalcium phosphate. This fertilizer has the advantage that it has

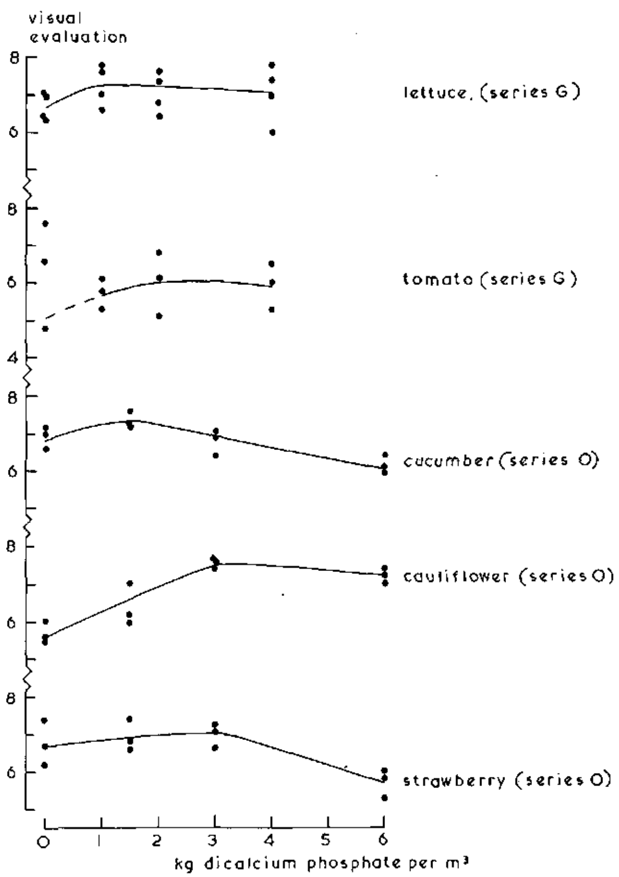
Table 17. Influence of the application of dicalcium phosphate to a potting mixture of 4 parts by volume black peat and 1 part by volume sand, to which 10 vol % farmyard manure was added, on the visually evaluated size of tomato plants (1 = very small, 10 = very large) (series C)

Fertilizers applied	kg dicalcium phosphate per m^3				Mean
	0	1.5	3	6	
only fertilizers	5.1	5.8	5.7	5.8	5.6
farmyard manure I	6.2	5.8	6.1	5.7	5.9
farmyard manure II	6.3	5.9	6.2	6.3	6.2

Statistical evaluation: manure I, II > fertilizer at $P = 0.05$.

Table 18. Phosphate content in Flujas mixture calculated as mg P_2O_5 per 100 g dry soil

Phosphate analysed in	P-getal	P-AL
dried soil sample	175	339
fresh soil sample	1026	591

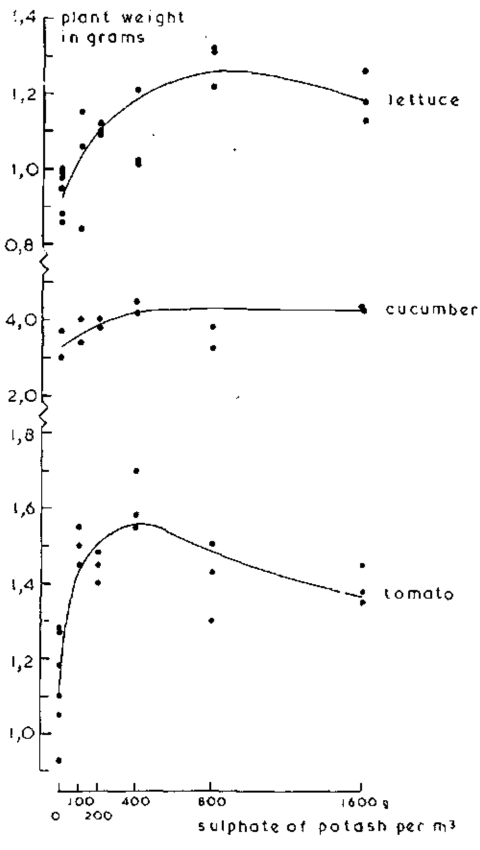


Statistical evaluation; *lettuce* no significant effects; *tomato* no effects; *cucumber:* negative linear effect significant at $P = 0.02$; *cauliflower:* positive linear and quadratic effect significant at $P < 0.01$; *strawberry:* quadratic effect significant at $P = 0.04$

Fig. 9 Influence of increasing applications of dicalcium phosphate to the Flujas mixture on the visually evaluated size of plants of some crops (1 = very small, 10 = very large) a high concentration and is sold in powder form. Applying a fertilizer in powder form is thought to be better than applying a granulated one, because the former can be more readily mixed with the potting mixture. The solubility of the dicalcium phosphate will not cause difficulties in the acid environment of the peaty mixtures. This is shown by chemical analysis for phosphate in the Flujas mixture, though some difficulties arise, see table 18. The analysis was carried out by the Laboratory for Soil and Plant Testing, Oosterbeek.

The estimation of phosphate extract in water (P-getal) of the fresh soil agrees best with the amount of phosphate actually added, viz. 1000 g P_2O_5 per 100 kg dry potting mixture. It is evident that the drying of the sample of the potting mixture decreases the solubility of phosphate.

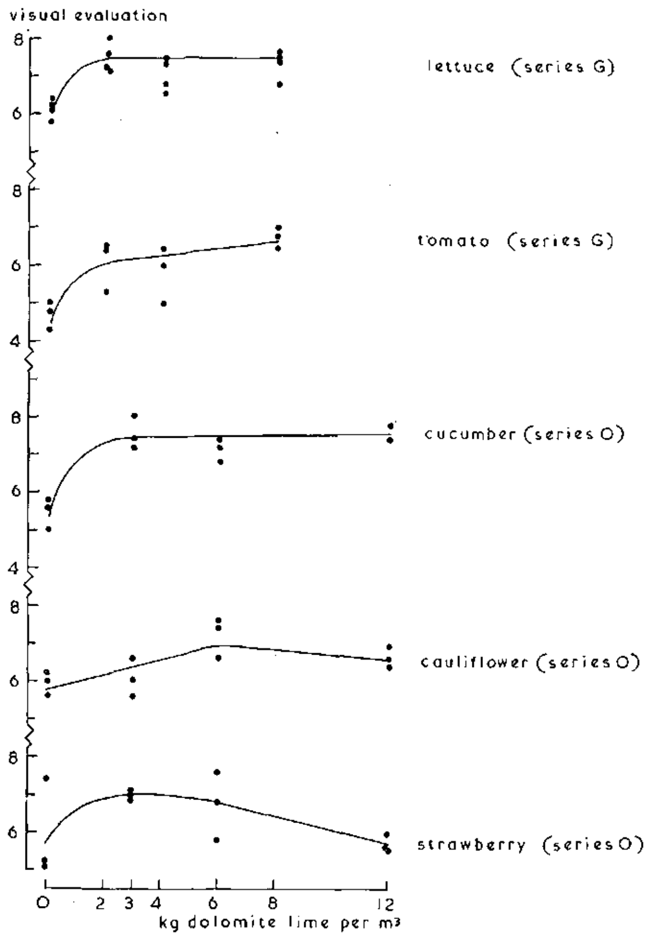
The influence of increasing application of phosphate on the visually evaluated plant



Statistical evaluation; *lettuce:* positive linear effect significant at $P < 0.01$, quadratic at $P = 0.01$; *cucumber:* no significant effects; *tomato:* positive linear effect significant at $P = 0.03$, quadratic at $P < 0.01$

Fig. 10 Influence of applications of sulphate of potash to the Flujas mixture on the fresh plant weight of some crops (series T) size of some crops is given in Figure 9. As is shown in this figure, 2 kg dicalcium phosphate may be considered as the optimal application, from the average of the results with various crops.

Potassium. In the beginning less attention was paid to the application of potassium because farmyard manure was added to the potting mixtures. Farmyard manure contains a high percentage of potassium. Flujas-mixtures with increasing applications of potassium were compared in only one series (T) with lettuce, tomatoes and cucum-

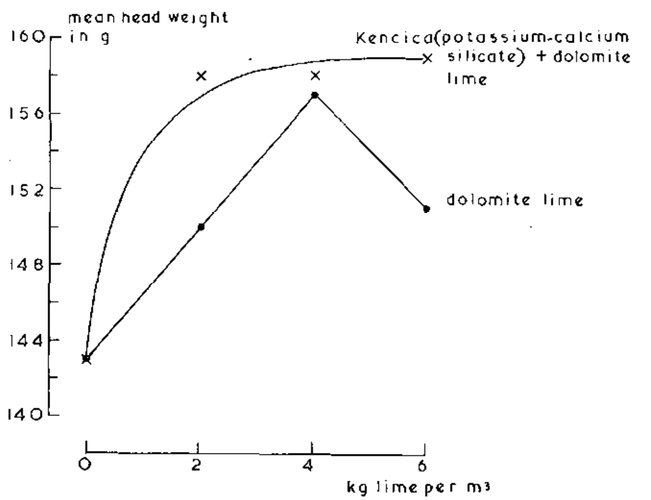


Statistical evaluation; *lettuce:* positive linear effect significant at $P < 0.01$, quadratic at $P = 0.02$; *tomato:* positive linear effect significant at $P < 0.01$; *cucumber:* positive linear and quadratic effect significant at $P < 0.01$; *cauliflower:* positive linear effect significant at $P = 0.03$, quadratic at $P = 0.04$; *strawberry:* quadratic effect significant at $P < 0.01$

Fig. 11 Influence of increasing applications of dolomite lime to the Flujas mixture on visually evaluated plant size (1 = very small, 10 = very large) bers. The plant weights were determined and were plotted out in Figure 10. From this figure it is shown that as an average more than 200 g K_2O per m^3 must be applied.

Lime. The influence of the applications of lime on the growth of lettuce plants is not clear when farmyard manure is added to the Flujas-mixture (see table 12). The response to plant growth of the application of lime to the Flujas mixture to which only fertilizers were added, is given in Figure 11. This figure shows that the omission of lime is unfavourable, because otherwise the curves are flat. 4 kg lime per m^3 was chosen as the optimal application. It cannot be said, however, that 3, 5 or 6 kg as an average will give less favourable results.

In series S with lettuce 2 kinds of lime were compared, viz. dolomite lime with 20% MgO (Dolokal supra) and a fifty-fifty per weight mixture of this dolomite lime and Kencica (potassium - calcium silicate). This trial was started in order to study a possible silicate effect of sand. The increasing applications of lime were therefore combined with increasing applications of dune sand (0, 10 and 20 vol %). The influence was significant only for the omission of lime, the visually evaluated plant size being smaller and the mean head weight being less. For the visual evaluation of plant size results were slightly better with dolomite lime (see table 10), whereas with the mixture of half dolomite lime and half Kencica the mean head weights were heavier (see Fig. 12). The differences between 2, 4 and 6 kg lime were very small, the application of 4 kg lime per m^3 being the best as an average.



Statistical evaluation; *dolomite:* positive linear and quadratic effect significant at P = 0.02; *mixture:* positive linear and quadratic effect significant at P < 0.01; omission of lime significant at P = 0.05

Fig. 12 Influence of increasing applications of limes (mean of the sand treatment) to the Flujas mixture on the mean head weight of lettuce in grams

Magnesium. The influence of magnesium was studied in series V by adding to the Flujas-mixture:

a. increasing applications of magnesium carbonate and simultaneously decreasing the equivalent quantities of calcium carbonate (chemical equivalent).

b. increasing applications of kieserite (magnesium sulphate) with an adequate application of calcium carbonate. The results are given in table 19.

Table 19. Influence of the application of magnesium fertilizers to the Flujas mixtures on the plant weight in grams of some crops

Crops	$MgCO_3$ (g per m^3)				kieserite (g per m^3)			
	0	715	1430	2145	0	1000	2000	4000
lettuce	0.62	0.60	0.65	0.60	0.61	0.62	0.62	0.61
tomatoes	4.6	4.1	4.2	4.4	5.0	4.6	4.6	4.2
cucumbers	8.7	7.7	7.8	8.0	8.3	9.5	9.5	9.2

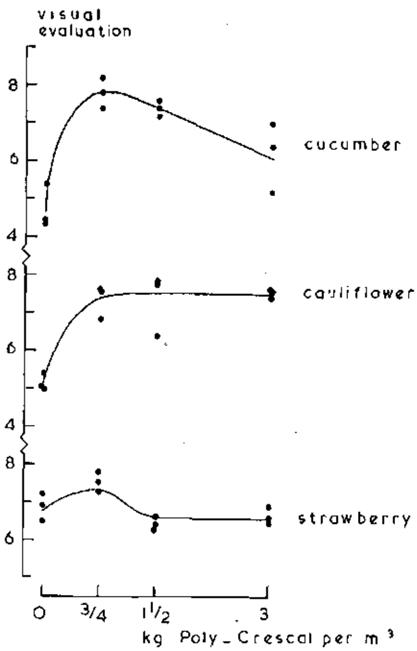
Statistical evaluation: *lettuce* and *cucumbers* no significant effects; *tomatoes*, linear negative effect of kieserite significant at $P = 0.02$.

No clear reaction of the young plants was obtained. The fact that the treatments without magnesium showing no distinct depression of growth, may be due to the fact that some magnesium was added by the other fertilizers e.g. 5 g MgO per m^3 was applied with 1 kg Poly-Crescal. Furthermore the magnesium content of peat moss and of black peat is probably not to be neglected (see under 2.2).

In practice in raising young plants, symptoms which look like magnesium deficiency ones will sometimes be observed especially with tomato plants which had to wait a longer time before planting out. For this reason it seems to be advisable to apply a quantity of magnesium to the potting mixture. This can be easily done by using a dolomite type of lime.

Compound fertilizers. Increasing applications of a compound fertilizer (Poly-Crescal) were compared in series O with the addition of only lime and dicalcium phosphate. Apart from these, trials with increasing applications of a NPK-fertilizer to lettuce and tomatoes have already be mentioned in the paragraph dealing with nitrogen. The results of series O are given in Figure 13. As with lettuce and tomatoes about 0.75 to 1 kg compound fertilizer per m^3 will be the optimal application.

Micro-elements. In series B the application of sodium molybdate and copper slag was studied with lettuce, to mixtures of 4 parts by volume peat moss or black peat, 1 part by volume clay or loam and 2 parts by volume sand to which fertilizers were added. The results are given in table 20. The differences are slight, but it may be concluded that the addition of copper slag is favourable with clay containing mixtures and that the addition of molybdate is so with loam containing mixtures. The molyb-



Statistical evaluation; *cucumber:* positive linear effect significant at P = 0.06, quadratic at P < 0.01; *cauliflower:* positive linear and quadratic effect significant at P < 0.01; *strawberry:* no significant effects

Fig. 13 Influence of increasing applications of Poly-Crescal to the Flujas mixture on the visually judged plant size of some crops (1 = very small, 10 = very large) (series O)

Table 20. Influence of copper or molybdate on the visually evaluated size of lettuce plants (1 = very small, 10 = very large)

Fertilizers applied per m³	peat moss clay sand	peat moss loam sand	black peat loam sand	black peat clay sand
no copper slag	3.5	4.5	4.4	4.9
1 kg copper slag	4.0	4.5	4.1	5.1
no molybdate	3.9	3.4	4.2	4.8
10 g sodiummolybdate	3.9	4.4	4.6	4.6

Statistical evalution ; fertilizers no significant effects; black peat > peat moss at P = 0.03.

date was always dissolved in water and poured on to the peat moss and/or black peat before mixing.

The same elements were compared with tomatoes in series C and applied to mixtures of 8 parts by volume black peat and 1 part by volume sand to which were added fertilizers alone or 10 vol % farmyard manure of 2 sources. The results are given in table 21. The addition of copper slag seemed to give good results. This was not the case with molybdate, especially when farmyard manure was added.

In series E the addition of ammonium molybdate and copper slag to the Flujas mixture with 10 vol % farmyard manure from two sources was studied with late let-

Table 21. Influence of copper or molybdate on the visually evaluated size of tomato plants (1 = very small, 10 = very large)

Fertilizers applied per m^3	black peat sand	black peat sand 10 vol % farmyard manure I	black peat sand 10 vol % farmyard manure II
no copper slag	5.7	5.9	6.6
1 kg copper slag	6.0	6.5	6.7
no molybdate	5.6	7.0	7.0
10 g ammonium molybdate	6.2	6.7	6.7

Statistical evaluation: manure I, II > fertilizers at $P < 0.01$; molybdate no significant effect; copper significant at $P = 0.05$, no significant interactions.

tuce. The results of the evaluation of size and mean head weight are given in table 22.

With one sample of farmyard manure the application of copper was favourable, with the other sample the application of molybdate.

In series I an attempt was made to study the influence of the most important micro-elements on a rather large scale with lettuce and tomatoes. First 7 Flujas-mixtures were made, to 4 of which 10 vol % farmyard manure from various sources were applied, to one 7.5 vol % clay was added, one only with normally used fertilizers without micro-elements and one to which was added a compound fertilizer with micro-elements (Poly-Crescal). Blocks were made from the mixtures. After some drying, but before pricking out, the micro-element solutions were poured on to the peat blocks. Unless otherwise stated, these solutions contained sodium molybdate, borax and copper sulphate, the percentages being such, that 5, 20 and 50 g were respectively added per m^3 of the potting mixture. Furthermore there were two solutions to which manganese and zinc sulphate were added in addition to the above mentioned percentages of micro-elements. The quantities are 200 g and 50 g respectively, calculated on the basis of 1 m^3 potting mixture. The results were summarized in table 23.

Table 22. Influence of the addition of copper slag and molybdate to the Flujas mixture to which farmyard manure was added, on the visually evaluated size of lettuce plants (1 = very small, 10 = very large) and in parentheses on the mean head weight in grams

Fertilizers applied per m^3	10 vol % farmyard manure I	10 vol % farmyard manure II
no copper slag	5.9 (172)	6.2 (179)
1 kg copper slag	6.4 (173)	6.3 (167)
no molybdate	5.9 (165)	5.1 (154)
10 g ammonium molybdate	5.7 (159)	6.9 (175)

Statistical evaluation: no significant effects of manure or fertilizers, interaction rate × kind of fertilizer × manure significant at $P = 0.02$ for plant size and at $P = 0.06$ for head weight.

Table 23. Fresh weight in grams of lettuce and tomato plants influenced by the addition of micro-elements to Flujas mixture with farmyard manure or with fertilizers only

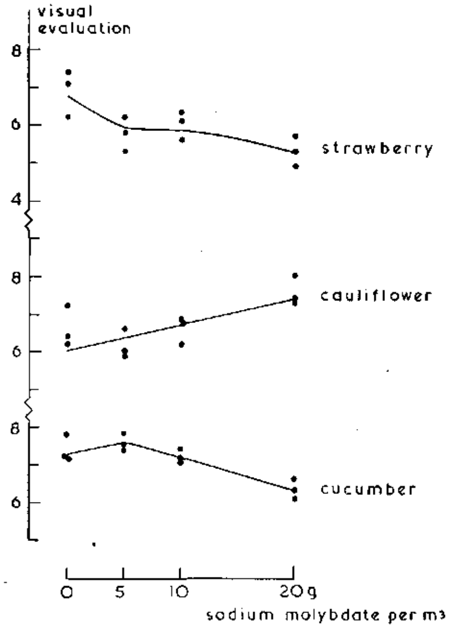
Micro-element fertilizers applied per m^3	lettuce			tomatoes		
	farmyard manure mean of 4 sources	simple fertilizers	Poly-Crescal	farmyard manure mean of 4 sources	simple fertilizers	Poly-Crescal
0 g sodium molybdate	2.75	2.53	2.53	2.16	2.25	2.45
5 g	2 95	2 54	2 99	2.16	2.28	2.31
10 g	2.79	2.80	2.89	2.16	2.05	2.51
0 g borax	2.89	2.71	2.98	2.13	1.89	2.43
12½ g	2.91	2.74	2.76	2.26	1.76	2.53
25 g	2.67	2.72	2.78	2.01	2.11	2.49
50 g	2.80	2.70	2.64	1.94	2.28	2.18
0 g copper sulphate	2.96	2.63	2.87	2.23	2.35	2.44
50 g	2,84	2.93	2.80	2.09	2.15	2.18
100 g	2.63	2.76	2.67	2.16	2.34	2.20
200 g manganese sulphate	2.60	2.33	2.34	1.89	1.90	2.16
50 g zinc sulphate	2.68	2.63	2.64	1.94	2.14	1.99

Statistical evaluation: *tomato* no significant effects: *lettuce*, manures > fertilizers at $P = 0.04$, copper linear negative effect significant at $P < 0.01$; molybdate, borax, copper > manganese, zinc at $P < 0.01$.

It seems that the application of molybdate is favourable in the case of lettuce, but it seems to have no effect on tomatoes. Comparison of the figures of farmyard manure with those of the fertilizers, shows that the first are based on four times the number of plants. With borax the pattern was rather clear when farmyard manure was added; a small application seems to be favourable. Lower plant weights were nearly always obtained by the addition of copper, manganese or zinc sulphate. It can be generally concluded from this trial that an addition of 5 g sodium molybdate and about 10 g borax per m^3 will be about the optimal application to the Flujas mixture for raising lettuce and tomato plants. It is out of the question that the additions of 50 g copper sulphate, of 200 g manganese sulphate and of 50 g zinc sulphate per m^3 may be above the optimum.

The results obtained with the Flujas mixture, to which 7.5 vol % clay was applied are not noted because this mixture gave practically a total failure with all treatments. The plants in blocks of this mixture did not grow and showed symptoms resembling burning. This failure is probably due to a great release of borium by the clay in the acid environment of the peat.

In series O the addition of molybdate to the Flujas mixture was studied with cucumbers, cauliflowers and strawberries. The results are given in Figure 14. As was expected, cauliflower needed much molybdate. The strawberries responded unfavourably.



Statistical evaluation; *strawberry:* negative linear effect significant at $P < 0.01$; *cauliflower:* positive linear effect significant at $P < 0.01$; *cucumber:* negative linear effect significant at $P < 0.01$

Fig. 14 Influence of increasing applications of sodium molybdate to the Flujas mixture on the visually evaluated plant size of some crops (series O)

In this series the addition of borax and of copper slag was also studied with the same crops (see table 24).

The addition of 10 g borax per m^3 seems to be favourable, whereas the addition of copper slag seems to be unfavourable with the exception of cucumbers.

According to the literature chromium has a favourable influence on cucumbers (REINHOLD und HAUSRATH 1941). A trial (series Y) was started with the application of potassium bichromate added to a Flujas mixture without farmyard manure and to a Flujas mixture to which 10 vol % farmyard manure was added (table 25). Furthermore the use of blocks and of clay pots was compared.

The influence of the bichromate is not clear. Contrary to the practice of REINHOLD and HAUSRATH, the quantity applied was smaller in order to prevent an excess. In consequence of this, no growth depression was obtained even with the largest application.

Table 24. Influence of the addition of borax or copper slag to the Flujasmixture on the visually evaluated plant size of some crops (1 = very small, 10 = very large)

Fertilizers applied per m^3	cucumber	cauliflower	strawberry
no borax	7.4	6.2	6.4
10 g borax	7.6	6.9	6.7
no copper	6.5	6.8	6.5
500 g copper slag	7.1	6.6	5.4

Statistical evaluation: no significant differences.

Table 25. Influence of the addition of chromiumto the Flujas mixture on the fresh weight of cucumber plants

Applied per m³		clay pot	peat block	mean
NO FARMYARD	0 g $K_2Cr_2O_7$	19.3	26.4	22.9
MANURE	2.5 g $K_2Cr_2O_7$	22.4	24.7	23.6
	5 g $K_2Cr_2O_7$	16.3	24.7	20.5
	10 g $K_2Cr_2O_7$	20.7	25.9	23.3
mean		*19.7*	*25.4*	
10 VOL %	0 g $K_2Cr_2O_7$	19.7	26.9	23.3
FARMYARD	2.5 g $K_2Cr_2O_7$	23.3	26.3	24.8
MANURE	5 g $K_2Cr_2O_7$	19.0	27.7	23.4
	10 g $K_2Cr_2O_7$	22.6	28.6	25.6
mean		*21.2*	*27.4*	

Statistical evaluation: chromium no significant effects, with peat blocks FYM > no FYM at $P = 0.02$.

The results with the application of micro-elements to the Flujas mixture are still more indistinct than for macro-elements. Even small impurities will be sufficient to supply the needs of the crops. The experiments showed that molybdenum and borium were particularly important. The sensitivity to micro-element deficiency was probably different for various crops. Except for cauliflower, lettuce seemed to be especially sensitive to molybdenum deficiency. PENNINGSFELD (1960) and REEKER (1959) also stated that cauliflower and lettuce were very sensitive to molybdenum deficiency. Besides molybdenum, according to German research workers (PENNINGSFELD 1960, REEKER 1957), copper is important. The response due to nutrients and micro-elements depends on the origin of the peat (PENNINGSFELD 1960).

Based on the results of the previous experiments, the following fertilizer application per m³ Flujas mixture was chosen: 3 kg dolomite lime; 1 kg Kencica (potash calcium silicate); 2 kg dicalcium phosphate; 1.25 kg Crescal; 5 g sodium molybdate.

These fertilizers were sold in pulverized form. Crescal was chosen instead of Poly-Crescal as it is much cheaper and the composition, except for the polyphosphate, is about the same. The only fertilizer that gives some difficulties in applying is the molybdate: it has to be dissolved in water. As Crescal contains 625 mg B, which is equal to 5 g borax, no extra borax was added. Kencica also contains some borium, the exact percentage being unknown (50 mg B ?).

The above-mentioned mixture can be used for all vegetable crops. For cauliflowers some more nitrogen or Crescal and more molybdate may be added. For cucumber a little less phosphate may be favourable (see next page). For strawberries a special application of 1 kg Floranid per m³ may be worth trying.

A comparison is now given of this fertilizer application for Flujas mixture with the results mentioned in literature.

According to the U.C.-system (BAKER 1957), to 1 m³ of a mixture of sphagnum peat and sand must be added: 6 kg lime partly as dolomite; 300 g P_2O_5 as superphosphate or triple superphosphate; 150 g K_2O; 150 g (–300 g) N, for the greater part as an organic (dried blood or hoof and horn); no micro-elements.

According to PENNINGSFELD (1959/60) to 1 m^3 peat must be added: 2 kg lime; 1.5 kg compound fertilizer (research was probably done with "Mairol", with 14% N, 12% P_2O_5, 14% K_2O, 0.1% Mn, 0.06% B, 0.04% Cu and 0.001% Zn); 15 g Fertrilon (Fe-EDTA manufactured by BASF); 5–10 g copper sulphate; 2 g sodium molybdate.

REEKER (1957) obtained about the same results, with perhaps a little more lime (3 kg per m^3).

Generally speaking there is good conformity, only the phosphate application for the Flujas mixture being remarkably higher. PENNINGSFELD (1959/60) has studied a doubled application of phosphate. As a mean of all the crops studied, the relative yield of dry matter production was 99.2 with 2 P (doubled application) if 1 P is fixed at 100. Lettuce and tomatoes responded favourably to the 2 P application, the relative yield of dry matter production being 102.5 and 104.8 respectively. A markable feature was a heavy depression in growth with (pickling) cucumbers with 2 P application, the relative yield being 86.0 It is noticeable that according to the research published here, cucumbers are also sensitive to a heavy phosphate application (see Fig. 9).

According to GEISSLER (1962) the phosphate dressing on the field may be omitted if sufficient phosphate is applied to the potting mixture; the addition of 16 to 35 kg superphosphate per m^3 is recommended. Apart from the results of these experiments it may be considered that a heavy application of phosphate is justified by the fact that phosphate uptake is decreased by low temperature (KOOT VAN 1958), as often occurs during the raising of vegetables. Such heavy applications are best applied in concentrated form.

The differences in lime application seem to be large, but they are of little importance (see Fig. 11). Beyond this it is possible that the peats used have different pH-values by nature.

According to the U.C.-system (BAKER 1957) application of micro-elements is unnecessary. The peats used in California possibly have a different micro-element content than those used in western Europe. In our opinion it seems more probable that the U.C. system is somewhat deficient in this respect. With the peats of Western Europe the omission of micro-elements may cause difficulties.

3.3.2 Growth stimulators and insecticides

According to Netherlands patent application, No. 22193 (PHILIPS GLOEILAMPEN FABRIEK N.V.) 2-methoxybenzonitril has a growth-stimulating effect, especially for young plants. In series M 2-methoxybenzonitril was tested. It was taken up in glycerol and then shaken in water in order to obtain an emulsion. The emulsion was poured on peat blocks in which tomato plants were pricked out. These were then rinsed with

Table 26. Fresh weight in grams of tomato plants influenced by increasing applications of 2-methoxybenzonitril to the Flujas mixture

doses	0	1	2	3	4
weight in g	2.4	2.1	2.2	2.0	1.7

Statistical evaluation: linear negative effect significant at $P < 0.01$.

water. After 14 days the tomato plants were cut and the fresh weight estimated (see table 26).

The doses, viz. about 0, 2, 4, 8 and 16 mg 2-methoxybenzonitril per peat block, are not exactly known because the growth stimulator in the emulsion was insufficiently dissolved.

For series O, 2-methoxybenzonitril was taken up in dolomite lime. In this way 0, 2.5, 5 and 10 cm^3 2-methoxybenzonitril (unformulated product) per m^3 were added to Flujas mixtures, the total lime application being equal. The following crops were cultivated: strawberries, cauliflowers and cucumbers. The results are summarized in table 27.

With strawberries the linear and quadratic influence of 2-methoxybenzonitril was significant.

In series Z 2-methoxybenzonitril was again tested with lettuce and strawberries. Apart from 2-methoxybenzonitril two other growth stimulators that were used by SINGH (1957), were tested in this series namely α-naphtoicacid and 1-hydroxynaphtoicacid. Results are given in table 29. Apart from these growth stimulators the application of heptachlor was tested. Insecticides are sometimes applied to the potting mixture in order to prevent damage due to wireworms and that due to the cabbage fly in the case of such crops as cabbage.

Table 27. Influence of 2-methoxybenzonitril added to the Flujas mixture on visually evaluated plant size (1 = very small, 10 = very large) and with cauliflower also on the percentage of heads with diameter larger than 27 cm (A-heads)

2-methoxy-benzonitril applied per m^3	Visual evaluation			% A-heads by cauliflowers	
	cucumbers	strawberries	cauliflowers	in reality	after correction to eliminate differences due to the cropping site
0 cm^3	7.6	6.2	7.6	63	65
2.5 cm^3	7.6	7.3	6.6	70	65
5 cm^3	7.6	6.4	7.4	66	65
10 cm^3	7.1	4.6	7.4	66	68

Statistical evaluation: *cucumber* and *cauliflower* no significant effects: *strawberry:* negative linear and quadratic effect significant at $P < 0.01$.

Table 28. Influence of insecticides applied to the Flujas mixture on the fresh weight of plants in grams (series R)

Applied per m^3	lettuce	tomatoes	cauliflower
untreated	2.19	1.37	1.24
250 g aldrin dust 25 %	2.43	1.25	1.10
250 cm^3 heptachlor emulsion 25 %	2.93	1.09	1.09

Statistical evaluation: *lettuce*, untreated, aldrin < heptachlor at P = 0.05; *tomato*, untreated, aldrin > heptachlor at P = 0.07; *cauliflower* no significant differences.

Table 29. Influence of some growth stimulators and heptachlor added to the Flujas mixture on the fresh plant weight in grams of lettuce and on the visually evaluated plant size of strawberries (1 = very small, 10 = very large) (series Z)

Applied per m^3	Lettuce plant weight in g	Strawberry plant size (visually evaluated)
0 g α-naphtoicacid	7.4	6.2
0.5 g	8.5	7.5
1 g	8.2	6.0
5 g	8.7	6.5
10 g	7.3	6.2
50 g	7.1	6.8
0 g 1-hydroxynaphtoicacid	8.9	4.1
0.5 g	8.3	6.9
1 g	7.6	5.6
5 g	7.4	5.5
10 g	9.0	6.9
50 g	8.0	4.1
100 g	6.7	6.9
0 cm^3 heptachlor (25 % emulsion)	8.1	6.7
10 cm^3	8.3	6.5
25 cm^3	6.8	6.8
100 cm^3	7.2	7.3
250 cm^3	7.4	7.1
500 cm^3	7.6	6.6
0 cm^3 2-methoxybenzonitril	8.7	6.0
0.5 cm^3	8.6	4.9
1 cm^3	7.4	6.8
2 cm^3	8.2	7.3
4 cm^3	8.9	7.1

Statistical evaluation: *lettuce*, 1-hydroxynaphtoicacid linear negative effect at P = 0.03, quadratic at P = 0.07; *strawberry*, 1-hydroxynaphtoicacid quadratic effect at P < 0.01, 2-methoxybenzonitril linear positive effect at P = 0.01, quadratic effect at P = 0.10.

In series R the application of 250 g aldrin dust 25% and 250 cm^3 heptachlor emulsion 25% per m^3 was compared with the untreated Flujas mixture. For results see table 28. No attention was paid to any insect damage as we were only concerned with plant growth. As the figures are very irregular, (see for example those of the 0-plots in table 29), it is not possible to draw an exact conclusion. On the one hand, we cannot entertain any great hopes concerning growth stimulator application, whereas the application of 2-methoxybenzonitril does have possibilities, for example with strawberries. However practical, application is still difficult because the application must be very exact, and there is the considerable danger of applying too much. The addition of the insecticides aldrin and heptachlor to the Flujas mixture is possible without severe growth depression. Whether it will be applied or not depends on the severity of pests and which control method is likely to be preferred, viz. the treatment of potting soils, the treatment in the field or perhaps others.

4 Flujas mixture

4.1 Properties of the Flujas mixture

From the amount of fertilizers applied to the Flujas mixture its nutrient content can be calculated. Furthermore this content can be estimated by chemical analysis. The analysis of some samples of the Flujas mixture is given in table 30.

The fresh weight of 1 m^3 loose Flujas mixture was estimated several times by weighing it in cases. By this method 340 kg was found to be the average. The larger the heaps used, the greater the compaction. Thus a motor-truck was loaded with Flujas mixture which was measured and weighed. This resulted in 362 kg m^3 before transport and 395 kg fresh weight per m^3 after transport over 15 km, the moisture content being 72.5%. Furthermore this experiment showed that, starting with 3 bales of peat moss and 1 m^3 black peat, the volume of potting mixture obtained was not 2 m^3, but 13% more with loose mixture. After being transported over 15 km this increase in volume was only 4%. The increase in volume is certainly not only due to incorrect measurement or weighing, but must be mainly attributed to changes in volume caused by

Table 30. The analysis of two samples of the Flujas mixture by the Government Agricultural Experiment Station, Maastricht (figures based on fresh weight)

total nitrogen (%)	0.30	0.35
nitrogen (N) soluble in water (%)	0.05	0.05
phosphoric acid (P_2O_5) soluble in mineral acid (%)	0.25	0.26
potassium (K_2O) soluble in water (%)	0.02	0.03
carbon dioxide (%)	0.15	0.3
magnesium (MgO) soluble in mineral acid (%)	0.10	0.23
moisture (104 °C) (%)	75.0	72.5
chloride (Cl^-) soluble in water (%)	0.05	practically absent
loss-on-ignition (minus carbon dioxide minus moisture) (%)	19.9	22.2
tarry materials (%)	0.06	practically absent
coal and/or carbonaceous components (%)	0.8	–
organic material (calculated) (%)	19.1	–
pH in water	5.7	–
salts soluble in water (%)	0.35	0.3
molybdenum (Mo) soluble in mineral acid (%)	0.0006	0.003
borium (B) soluble in mineral acid (%)	0.0004	0.0005

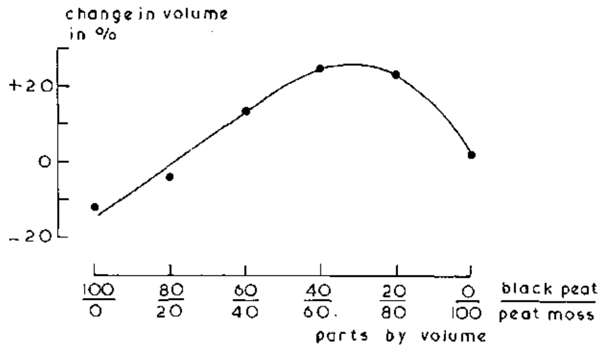


Fig. 15 Change in volume due to the mixing and crushing of different ratios of black peat and peat moss

mixing and crushing. Thus it was found that 1 m^3 black peat after mixing and crushing had shrunk, that mixed and crushed peat moss kept the same volume, and that the mixtures of both black peat and peat moss increased in volume after mixing and crushing (see Fig. 15).

Starting with a fresh weight of 375 kg per m^3 for the Flujas mixture and the mean of the analysis of table 30, a comparison can be made between the quantity of nutrient added and the content found by analysis (table 31).

The dry weight, about 104 kg per m^3, was calculated from the fresh weight and moisture content of the Flujas mixture. By weighing dried peat blocks of different dimensions it was calculated how many blocks can be pressed out of 1 m^3 of Flujas mixture (see table 32). Except for the peat blocks for cauliflower the blocks used are almost cubic. In practice the "diameter" is usually in fact the average measurement of the upper edge. The blocks for cauliflower were hexagonal columnar in shape and for this block the smallest diameter was measured.

For strawberries a peat block with a special, large planting hole was used; the same block with a smaller hole was used for cucumbers. Of the latter a smaller number will be pressed out of 1 m^3 Flujas mixture. The relation between the diameter of the peat blocks and the number of blocks from 1 m^3 Flujas mixture is shown in Figure 16 on double logarithmic paper. This figure also shows the number of blocks that can be

Table 31. Comparison of the quantity of nutrients added to 1 m^3 Flujas mixture and the analysed content

Added quantity of nutrients	Analysed quantity of nutrients *(soluble in)*
177 g N	185 g N *(water)*
1000 g P_2O_5	925 g P_2O_5 *(mineral acid)*
225 g K_2O (175 g soluble in water and 50 g in mineral acid)	100 g K_2O *(water)*
625 + 50 mg B	1.5 à 2 g B *(mineral acid)*
2.33 g Mo	1.5 g Mo *(mineral acid)*

Table 32. Number of peat blocks that can be pressed out of 1 m³ of Flujas mixture

Crop to be raised	Number of blocks in plant tool	Diameter in cm	Dry weight of the blocks in g	Number of blocks of 1 m³
lettuce[1])	6	4	17.4	5750
lettuce	4	5	24.9	4000
gherkins[1])	4	6	34.5	2700
cauliflower[1])	2	7.5	63.7	1570
tomatoes	2	8	78.7	1270
strawberries	1	12	236.5	423

[1]) These plant tools were not used in the other part of the investigation.

theoretically made from 1 m³, assuming the blocks to be exactly cubic and that no compaction occurs. It is shown that the actual number of blocks pressed out of 1 m³ is less than the theoretical number and that this difference increases with the smaller blocks. This fact can be explained by a higher compression of smaller blocks in comparison with larger ones. Furthermore, the ratio between the height and the diameter of the blocks is less with a larger diameter, this ratio being about 1,2 with small blocks

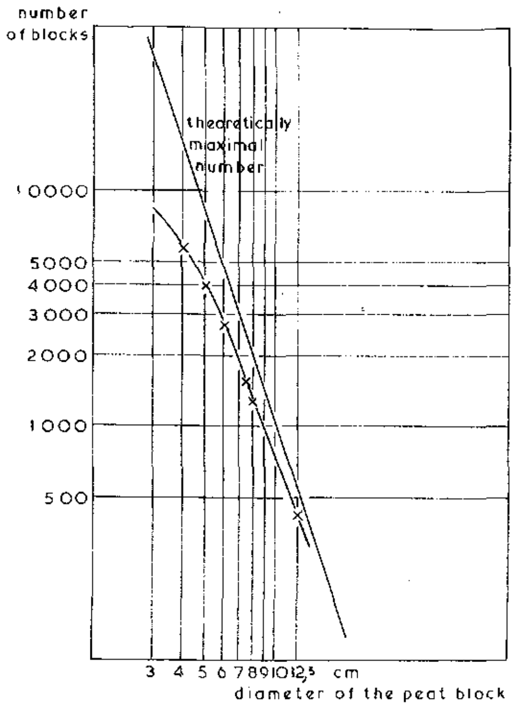


Fig. 16 Number of peat blocks theoretically and practically to be pressed out of 1 m³ Flujas mixture dependent on the diameter of these blocks

and 1.0 to 0.9 with larger ones. According to the figures of table 8 the number of peat blocks that can be pressed from 1 m^3, mentioned in table 32 and figure 16, not only applies to the Flujas mixture but also to other peaty potting mixtures.

The number of peat blocks pressed from 1 m^3 Flujas mixture being known, the amount of nutrients in each block can be calculated. Following TEPE (1952, 1953), the uptake of nutrients by the crop is compared with the amount of nutrients present in the blocks. Table 33 shows the nutrient content of the aerial part of young plants grown in Flujas mixture.

The uptake of macro-elements by young plants is calculated from the figures in table 33 (see table 34). This table also shows the quantities of nutrient present in the peat blocks used. These quantities were calculated from the amount of fertilizers added to 1 m^3 Flujas mixture.

The figures in table 34 show that even if larger plants are raised, the nutrient content of blocks of Flujas mixture is amply sufficient to supply the nutrient requirements of young plants. Considerably heavier tomato plants were raised by SPITHOST (1962). The nitrogen uptake of these plants was estimated to be 100 mg N per plant.

The article by ROORDA VAN EYSINGA en MARTENS (1962, 1963) gives detailed information on the pressure resistance, elasticity, decreasing volume with drying and the soil: water: air-relationship of peat blocks made from Flujas mixture. Figure 5 also gives a survey of the content of solid materials and available water in the Flujas mixture. The pF-curve of peat blocks made from the Flujas mixture is shown in Figure 17 (this peat block was made according to method c stated below).

One problem that occurs in estimating the pF curve is the filling of the rings for sampling. During this investigation different methods were tested:

a measuring of volume and weight of the peat blocks made with a plant tool, conversion into 100 cm^3 and filling the rings (with a volume of 100 cm^3) for pF estimation with an adequate quantity of potting mixture.

b placing of a ring in the wholly or partly filled modeller of the plant tool and subsequent stamping of this plant tool into the heap of wetted potting mixture.

c placing of the ring in the model press according to the description given by ROORDA VAN EYSINGA en MARTENS (1962).

Table 33. Nutrient content in the aerial part of young plants

Crop	Variety	Mean fresh weight of the plants in g	Dry matter %	% of dry matter N	P_2O_5	K_2O	CaO	MgO
lettuce	Wonder van Feltham	7 to 8	4.6	5.70	2.84	10.40	2.37	0.64
lettuce	Pr. Blackpool × Interrex	3.9	4.1	5.95	2.16	4.17	1.70	0.85
tomatoes	Victory	5.6	6.8	4.80	2.62	10.48	2.45	1.26
cucumbers	Groene Standaard	12.7	5.4	4.96	1.97	11.26	2.10	0.95

Table 34. Uptake of macro-elements by young plants and the quantity present in the peat blocks

Crop	Fresh weight of young plants	N in mg	P_2O_5 in mg	K_2O in mg	CaO in mg	MgO in mg
lettuce (W. v. F)	7.5 g	21	9 5	38	9	2.5
lettuce (PB × I)	3.9 g	9.5	3.5	7	3	1.5
peat block (diameter)	5 cm	44	250	56	500	37
tomatoes	5.6 g	13.5	7.5	29.5	7	1.5
peat block (diameter)	8 cm	117	667	150	1330	100
cucumbers	12.7 g	34	13.5	77	14.5	6.5
peat blocks (diameter)	12 cm	350	2000	450	4000	300

Method a is difficult to perform with accuracy. Method b seems to have the disadvantage of some arbitrariness and to be more irregular in results. As was found in a few cases method c gives a fresh weight that is 5% too low. Moreover the elasticity and changes in volume caused by drying give greater difficulties in respect to the determination of the soil: water: air-relationship in peat blocks of Flujas mixture, as was shown by ROORDA VAN EYSINGA en MARTENS (1963).

The estimation by VAN DIJK of the water uptake at saturation point of a previously air-dried product and of humification value (OVERBECK and SCHNEIDER's "Humifizierungszahl") is also given in the publication by ROORDA VAN EYSINGA en MARTENS (1963).

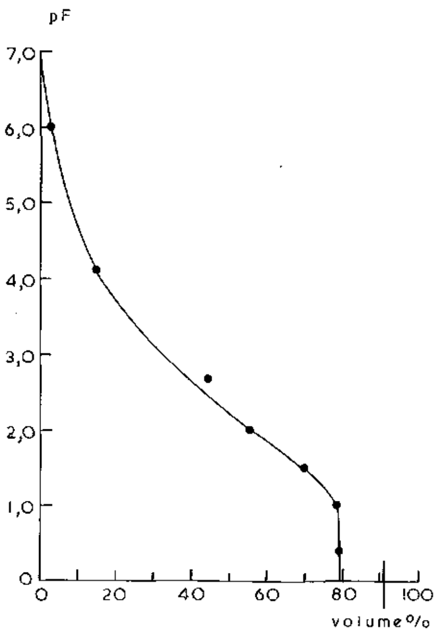


Fig. 17 pF curve of peat blocks made from the Flujas mixture (series P)

4.2 Introduction of the Flujas mixture

During this investigation Flujas mixtures were distributed twice among growers in order to compare them with the potting soils generally used. The first Flujas mixture (series F) was made with the addition of 10 vol % farmyard manure. The results of this comparison of Flujas mixture were, with lettuce: 23 trials, of which 18 were better, 4 were equal and one was a failure,
with tomatoes: 14 trials of which 11 were better, 2 were equal and 1 was slightly inferior to the traditional potting soils.

In one case the cause of the failure with lettuce could not be found. The results of comparing the second Flujas mixture (series L) were: 35 trials with tomatoes, of which 27 were better, 7 were equal and 1 was slightly inferior to the ordinary potting soils.

The Dutch law relating to trade in fertilizers, manures and potting soils does not provide for the inspection of the quality of the potting soils on the market. The trade-mark Flujas for a potting soil was therefore registered in the name of "Noord Limburg" Experimental Horticulture Substation with the Bureau International pour la Protection de la Propriété Industrielle (International Office for the Protection of Industrial Property), Geneva. The Substation places the trade-mark at the disposal of any bona-fide potting soil manufacturer. These manufacturers must meet certain requirements and be willing to manufacture the Flujas mixture according to the recipe and under regular inspection.

Leaflets with the recipe for Flujas mixture with the addition of 10 vol % farmyard manure were distributed to growers in the north of Limburg region. The recipe was: add per m^3 of a mixture of equal parts by volume of black peat and peat moss: 1 wheelbarrow (approx. 100 l) of old farmyard manure, 4 kg dolomite lime, 2 kg di-calcium phosphate, 0.75 to 1 kg nitrochalk and 5 g sodium or ammonium molybdate. The recipe makes provision for an addition of 10 vol % farmyard manure in order to prevent the occurrence of any serious results due to any mistake being made by growers. The results obtained with potting mixtures made more or less in this way were good. The manufacturers of potting soils have tended to change the composition of their soils to that of the Flujas mixture, again with good results. The commercial potting soils included in the various series for comparison, gave bad results, especially in the first part of this investigation. Lateron the commercial potting soils improved.

In the manufacturing of Flujas mixture peat crushing will give no difficulty due to the fact that half the ingredients consist of relatively dry peat moss. In our opinion a high-speed mill with a speed of at least 1500 r.p.m. is the most suitable machine for crushing. With such a machine even the Phragmites peat fibres were sufficiently crushed.

A more difficult problem in the large-scale manufacture of potting mixture is to obtain a thorough mixing. Most manufacturers of potting soils have tried to solve this problem, but none have been completely successful.

When peat moss is used as part of the potting mixture the mixing of the fertilzers can be improved by previously mixing it with the relatively dry peat moss.

5 Discussion and conclusions

As was stated in the Introduction, this investigation did not express any clear opinion about the physical properties of a good potting mixture for making soil blocks. It was found that a potting mixture for making soil blocks must be of a soft, uniform and slightly sticky consistency. When these qualities are present the soil blocks become easier to press out and also more robust. This sticky quality, except when clay or mud containing materials are used, can only be obtained by using decomposed peat. Attempts to obtain this stickiness artificially had to be stopped as being without prospects. The disadvantage of using decomposed peat is the fact that it becomes unwettable after drying.

Little information was found concerning the optimal soil: water: air – relationship. In our opinion this problem brings us back to the question: what is the lowest permissible air content? We may assume that the solid content must be as low as possible and that the content of available moisture as large as possible. We think we found some indications that weather conditions have a bearing on the influence of the soil: air: water relationship on crop growth. In spite of some attempts we failed to prove this theory.

This investigation has given clearer results concerning the nutrient requirements of a good potting mixture. The fact that there is a considerable toleration in regard to the nutrient content was also concluded by Reeker (1957). According to the U.C. manual (Baker 1957) more crops can be cultivated in one and the same mixture. This is generally confirmed by our investigation. But we obtained some indications that with cauliflower, for example, a different nutrient content is required than with lettuce and tomatoes. For cucumbers more research about the optimal chemical conditions seems to be desirable. The extremely large application of phosphate, as was found favourable in this investigation, has already been discussed (see 3.3.1.)

The addition of growth stimulators seems to have no practical possibilities at the moment. The addition of insecticides seems to be more promising as they give at least no clear depression of growth.

No attention was paid to the micro-organisms of peat blocks. According to the U.C. manual (Baker 1957) controlled colonization would be worth trying in order to retard pathogens. In our opinion by excavating the black peat and thus changing the environment from anaerobic to aerobic, and by liming the peat, conditions would be made favourable for controlled colonization. A bacterial fertilizer is added to the potting mixture in Russia (Rada 1957).

According to an investigation made by the Dutch Plant Pathological Service, no parasitic nematodes were found in Flujas mixture. This was according to expectation, in view of the origin of the components. Sterilization of the Flujas mixture is unnecessary. According to PENNINGSFELD (1960) sterilization of a peat potting mixture is usually unnecessary. According to the U.C. manual sterilization is necessary.

For the investigation, described here, the plants were raised as far as possible by means of the most common method. Troublesome differences in growth occurred between the replicates of the various treatments. A great number of factors influenced these. Some of these factors were indicated and measures taken to eliminate them. The following factors can be mentioned:

a the plant size of the seedling. The plant size at planting out being of influence on the yield; the size of the seedling will also influence the size of the plants to be planted out. If no special instructions are given to the workers in charge of the job of pricking out they will tend to prick out the larger seedlings first and the smaller ones later.

b uniformity in the manner of pricking out. This depends on the person who does it. In this investigation the aim was to have one person to prick out one or more complete replicates.

c the weather conditions during pricking out. With the larger trials it was not possible to prick out all the plants in a short period. As a result some plants will be exposed to unfavourable conditions for longer times than others. The plants pricked out in the hottest part of the day or even earlier will suffer more than plants pricked out in the evening.

d the heterogenity of the potting mixtures. In the later series an attempt was made to mix one large heap of potting mixture subdivided into the different potting mixtures by the application of the individual treatments to be studied. Of course this is only possible if the basic composition is the same.

e the moisture content of the potting mixture. This content influences the physical properties of the blocks made from it. When the potting mixtures of one trial are of the same basic composition the moisture content can be standardized. At the end of this investigation 250 l water was used to wet 1 m^3 Flujas mixture. With different basic compositions the application of water is difficult if not impossible to standardize. In the beginning of the investigation the application of water to the potting mixtures was left to the judgement of the workers at the experiment station. They were told to make the potting soils as wet as possible. The reason for this was that it was considered unfavourable to make a potting soil too wet and that we wished to test the mixtures under such unfavourable conditions.

f the influence of the position of the plants in the plant bed. Sometimes a correction is possible. Drops of water due to rain or condensation, these having an irregular pattern, however, often caused difficulties in this investigation.

The idea of making blocks of peat is not new. BROWNING (1957) described the raising of tomato plants in peat blocks. In a communication of STATENS FORSØGVIRKSOMHED I PLANTEKULTUR (1960) peat or sphagnum pots are described which were made by cutting raw peat into pieces, in the middle of which a hole was bored. ŠUIN *et al.*

(1958) used sedge tufts soaked in dung water for growing tomatoes and cucumbers and for raising seedlings. In "de Tuinderij" of about 1929 there were advertisements for factory-made peat pots.

The use of peat as a growth substratum for intensive horticulture is meeting with increasing interest all over the world.

Advantages and disadvantages of the Flujas mixture. Such advantages and disadvantages of the Flujas mixture are now summarized according to the opinion of the author.

1 The potting mixture meets the requirements of the objective of the study, namely the basic components are at present obtainable in sufficient quantities and will be for many years to come.

2 provided suitable machinery is used, the composition is of reasonable homogeneity. According to EGBERTS en VAN DER KLOES (1960) a good homogeneity is only to be obtained by manufacturing in a factory. Unlike, for example, a mixture of black peat and fresh (wet) sphagnum peat the Flujas mixture is reasonably easy to manufacture. When the peat moss bales used for the manufacturing are correctly stored, the moisture content of the Flujas mixture can be kept within reasonable limits.

3 the Flujas mixture is easy to handle and press into blocks. These peat blocks have favourable physical conditions and are robust. Another advantage of the blocks is their light weight.

4 the growth of many vegetable crops in peat blocks of the Flujas mixture with one and the same chemical property is very good.

Apart from these points included in the objective of the study the following advantages can be noted:

5 the Flujas mixture naturally contains no pathogens or weed seeds and need not be sterilized.

6 unlike the potting soils which contain a larger percentage of mineral materials the Flujas mixture improves the soils in which it ultimately comes to rest. At least a large part of the Flujas mixture consists of high-grade peat. PENNINGSFELD (1960) remarked on this subject that, if peat moss must be used as a manure, it is advantageous first to use it as a growth substratum.

Disadvantages:

1 although it was not found in our experiences, the presence of Phragmites peat in the black peat may cause difficulties in the manufacture of the Flujas mixture.

2 the use of the black peat renders the Flujas mixture partially unwettable after drying.

3 frost and drought and especially an excessive rainfall can adversely affect the Flujas mixture. The stickiness of the mixture will be lost by frost and drought and hence the resulting blocks will be less robust and less easy to press out. The leaching of nitrogen by rain causes great difficulties in practice. This can be prevented by using freshly made potting mixture or by storing the potting mixture under a plastic sheet.

Summary

1 The soil block is a clod made by compressing potting soil with a plant tool and it serves as a rooting substratum for young plants. The trade in potting soils in the Netherlands started in 1942 and is still developing.

2 The investigation included trials with series of potting mixtures. Description of the series (see Appendix) and the used materials.

3.1 The plant size at planting out time influences the yield. Tall plants result in an earlier yield than smaller ones.

3.2 Potting mixtures with clay or loam were less promising. Mixtures of black peat and peat moss were satisfactory, the 1 to 1 ratio in parts by volume lies in the optimal range. This one to one mixture of black peat and loose peat moss of bales is named Flujas mixture. The influence of the addition of sand to the Flujas mixture on plant growth varied.

3.3 Farmyard manure had a levelling effect on the results of experiments with fertilizer applications to the Flujas mixture. The optimal fertilizer application has wide limits. As the standard application for 1 m^3 Flujas mixture was chosen: 3 kg dolomite lime, 1 kg Kencica (blast-furnace slag being potassium calcium silicate), 2 kg dicalcium phosphate, 1.25 kg Crescal (14% N, 10% P_2O_5, 14% K_2O and minor elements) and 5 g sodium molybdate. For strawberries, cauliflower and perhaps cucumbers a slightly different fertilizer application may be favourable. The application of growth stimulators gave practically no results. The application of insecticides proved to be a possibility.

4.1 The number of peat blocks from 1 m^3 potting mixture was estimated. So was the nutrient content in peat blocks with various diameters and the nutrient uptake by young plants.

4.2 Trials with Flujas mixture in practice gave good results.

5 The advantages and the disadvantages of Flujas mixture are mentioned.

Samenvatting

1 De perspot is een kluit grond die door samendrukken van potgrond met een pottenpers wordt verkregen en die dient als bewortelingssubstraat voor de jonge plant. De handel in potgrond in Nederland is in 1942 begonnen en ontwikkelt zich nog steeds.

2 Het onderzoek omvat proefnemingen met series potgrondmengsels. Beschrijving van de series en van de gebruikte materialen.

3.1 De grootte van de plant bij het uitpoten heeft invloed op de opbrengst. Een grote plant geeft vooral een vroegere opbrengst dan een kleine.

3.2 Potgrondmengsels waarin klei of leem was verwerkt boden weinig perspectief. Mengsels van vers zwartveen en turfmolm voldeden goed, de verhouding 1 op 1 in volume delen ligt in het optimale gebied. Dit 1 op 1 mengsel uit vers zwartveen en turfmolm van fijngemaakte balen wordt Flujas-potgrond genoemd. De invloed van toevoeging van zand aan Flujas-potgrond op de groei van planten was wisselend.

3.3 Stalmest werkt nivellerend op de resultaten van proefnemingen met voedingselementen bij Flujas-potgrond. Het optimale gebied voor de meststofdosering is ruim. Als standaarddosering voor 1 m^3 Flujas-potgrond is gekozen: 3 kg koolzure magnesiakalk, 1 kg kalikiezelkalk, 2 kg dubbelkalkfosfaat, 1,25 kg Crescal (14+10+14 plus sporenelementen) en 5 g natriummolybdaat. Voor aardbei, bloemkool en misschien komkommers kan een afwijkende dosering gunstig zijn. Toevoeging van groeistoffen gaf weinig resultaat. Toevoeging van insecticiden bleek mogelijk.

4.1 Het aantal perspotten uit 1 m^3 veenrijke potgrond wordt berekend. Evenzo het gehalte aan voedingsstoffen in perspotten van verschillende grootte en de onttrekking aan voedingselementen door jonge planten.

4.2 Beproeving van Flujas-potgrond in de praktijk gaf goede resultaten.

5 Voor- en nadelen van Flujas-potgrond worden vermeld.

Zusammenfassung

1 Der Presstopf ist eine Zusammendrückung einer gärtnerischen Erde, die als Bewurzelungsraum für die Jungpflanze dient.

2 Die Untersuchung umfasst verschiedene Reihen von Erdmischungen. Beschreibung dieser Reihen (in Appendix) und der benutzten Materialien.

3.1 Die Pflanzgrösze beim Auspflanzen hat Einflusz auf den Ertrag. Grosze Pflanzen geben einen früheren Ertrag als kleine.

3.2 Gärtnerische Erden, worin Ton oder Lehm verwendet worden waren, boten wenig Aussicht. Mischungen von frischem Schwarztorf und Torfmull bewährten sich gut, das Verhältnis 1 zu 1 volumenmässig liegt im Optimalbereich. Die Mischung von 1 Teil frischem Schwarztorf und 1 Teil aufgelockertem Torfmull aus Ballen wird "Flujas-Erde" genannt. Der Einflusz von Sandzusatz zu Flujas-Erde war verschieden.

3.3 Stalldung wirkt ausgleichend auf die Erfolge von Versuchen mit Nährstoffzusatz zu Flujas-Erde. Der Optimalbereich für Nährstoffzusatz ist gross. Als Einheitsdosierung für 1 m^3 Flujas-Erde wurde gewählt: 3 kg magnesiumhaltiger kohlensaurer Kalk, 1 kg Kali-kieselsaurer Kalk; 2 kg Doppelt-kalkphosphat, 1,25 kg pulverförmiges Crescal (14% N, 10% P_2O_5, 14% K_2O mit Spurenelementen) und 5 g Natriummolybdat. Für Erdbeeren, Blumenkohl und vielleicht Treibgurken ist ein abweichender Nährstoffzusatz günstig.
Zusatz von Wuchsstoffen hatte wenig Erfolg, derselbe von Schädlingsbekämpfungsmitteln erwies sich als möglich.

4.1 Die Anzahl der aus 1 m^3 reinem Torfgemisch herzustellenden Presstöpfe wurde bestimmt. Der Nährstoffgehalt in einzelnen Töpfen verschiedener Grösse und die Nährstoffaufnahme bei Jungpflanzen wurde verglichen.

4.2 Versuche mit Flujas-Erde in der Praxis gaben gute Erfolge.

5 Vor- und Nachteile der Flujas-Erde werden erwähnt.

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Appendix

Description of the series

Series A.

This series contained 12 potting mixtures, viz. some commercial potting soils, the home made potting soil from the Venlo Experiment Station. The latter contained different ratios of town refuse. There were also some other mixtures. Full details will be found in the 1958 annual report of Proeftuin "Noord-Limburg". The mixtures were made in November 1957. Seedlings of Mayqueen lettuce were pricked out into the soil blocks and raised under rows of Dutch lights. Seedlings of Victory tomatoes were pricked out into clay pots and raised in a hothouse. Immediately after pricking out the plants were replicated once only. Planting out is done along the outside parts of an unheated Dutch light structure on a sandy soil. Lettuce is then planted out in 2 replicates, tomatoes in 4 replicates. This trial was a small one, a small number of lettuce and tomato plants being used.

Series B.

This series contained more than 300 potting mixtures made in the autumn of 1958. The series was subdivided into groups and sub-groups and there were some extra mixtures.

For the physical part of this series the scheme was: a, b, c.
a, b, c means respectively 11 mixtures of:
peat moss, clay and sand;
peat moss, loam and sand;
black peat, loam and sand;
black peat, clay and sand (scheme 1).

Scheme 1. Scheme for the physical part of the series in parts per volume

	Physical part of the series in parts per volume										
a	4	4	4	4	4	4	4	4	4	4	4
b	1	0	1	2	0	2	4	0	4	4	2
c	0	1	1	0	2	2	0	4	4	2	4

The sand used in this mixtures was a non-calcareous river sand. For a further description of these materials see 2.2.

To these 44 mixtures there were added:

a fertilizers

b fertilizers with 25 vol % cocoa organic lime

c fertilizers with 10 vol % farmyard manure

d fertilizers with 10 vol % townrefuse DANO

For the chemical part of this series use was made of mixtures of:
peat moss, clay and sand;
peat moss, loam and sand;
black peat, clay and sand;
black peat, loam and sand
in 4:1:2 parts per volume. The sand used in this mixtures was a non-calcareous river-sand.

To these 4 mixtures were applied:

a fertilizers

b 10 vol % farmyard manure of one source

c 10 vol % farmyard manure of another source with addition of 4 different applications of phosphate, 4 different applications of lime.

The first four mixtures with fertilizers were also compared with and without molybdate, with and without pulverized copper slag and three times with 30 vol % cocoa organic lime of different sources.

The extra mixtures were some commercial potting soils and the best potting mixtures from series A.

Mayqueen lettuce was pricked out in December. Three plates were filled from each mixture and each plate was placed on a different plant bed.

When the plants reached planting out stage, plants of 56 mixtures were planted out to estimate the correlation between plant size at the time of planting out and the yield at the end of the culture. Plant size was visually evaluated. The plants which were planted out from the 56 mixtures were so selected as to ensure the maximum possible a variation in plant size. They were planted out in an unheated Dutch light structure on a sandy soil.

Series C.

The whole series contained 190 potting mixtures which with some exceptions were made in March 1959. This series was subdivided into a physical and a chemical part and there were some extra mixtures. The physical part was subdivided into 2 groups, namely a group on black peat base and one on peat moss base.

Scheme 2 gives the 28 potting mixtures on black peat base (figures indicating parts per volume).

Scheme 3 gives 60 potting mixtures on peat moss base.

For the chemical part of this series use was made of a mixture of 8 parts per volume black peat and 1 part noncalcareous river sand with addition of 10 vol % farmyard manure of 2 sources.

Scheme 2. 28 potting mixtures on black peat base (figures indicating parts per volume)

	Potting mixtures															
black peat	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
noncalcareous river sand	0	2	4	8	0	2	4	8	0	2	4	8	0	2	4	8
loam					1	1	1	1								
clay									1	1	1	1				
20 vol % farmyard manure of source II													+	+	+	+

	Potting mixtures											
black peat	8	8	8	8	8	8	8	8	8	8	8	8
noncalcareous river sand	0	2	4	8	0	2	4	8	0	2	4	8
loam					1	1	1	1				
clay									1	1	1	1
10 vol % farmyard manure of source II	+	+	+	+	+	+	+	+	+	+	+	+

Scheme 3. 60 potting mixtures on peat moss base (figures indicating parts per volume)

	Potting mixtures																	
peat moss	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
clay[1])	1	1	1	2	2	2	1	1	1	2	2	2	1	1	1	2	2	2
non calcareous river sand	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2	0	1	2
10 vol % farmyard manure of source I							+	+	+	+	+	+						
20 vol % farmyard manure of source I													+	+	+	+	+	+

	Potting mixtures											
peat moss	4	4	4	4	4	4	4	4	4	4	4	4
clay[1])	1	1	1	2	2	2	1	1	1	2	2	2
non calcareous river sand	0	1	2	0	1	2	0	1	2	0	1	2
10 vol % farmyard manure of source II	+	+	+	+	+	+						
20 vol % farmyard manure of source II							+	+	+	+	+	+

[1]) Another 30 potting mixtures were obtained when clay is displaced by loam

The following were compared:
4 different applications of lime;
4 different applications of phosphate;
4 different applications of a NPK fertilizer in powder form;
4 different applications of dried blood;
4 different applications of urea;
with and without pulverized copper slag;
with and without molybdate;
addition of 5 vol % clay;
addition of 5 vol % loam;
addition of 10 vol % cocoaorganic lime;
addition of 20 vol % cocoaorganic lime.

The 18 extra potting mixtures were commercial potting soils and the best potting mixtures from series B.

The tomatoes pricked out were of the Victory variety. The soil blocks were then placed in a hothouse. When the plants had to be spaced out some were placed in an unheated movable Dutch light structure. Here the differences in growth became clearer. Of the latter, plants in 42 mixtures were planted out in two replicates in an unheated Dutch light structure on a sandy soil to estimate yields. The duplicates were obtained by adding together the original four replicates (4 plates) in pairs. The 42 mixtures were so selected that large, medium and small plants were in the same proportion.

Series D.

The mixtures belonging to this series consisted of black peat and peat moss or of frozen black peat and peat moss. To the latter mixture CMC was added according to the theory of EGBERTS and VAN DER KLOES (1960). CMC, viz. carboxyl methyl chlorid, was added as an artificial sticking material. The mixtures were examined with regard to the possibility of making firm blocks from them and the ease of making these blocks. Furthermore, in the case of the peat moss black peat mixtures the edge of the block was measured immediately after pressing. No crop was cultivated in these blocks.

Series E.

This series contained 45 potting soils made in the summer of 1959. It was started in order to study the optimal application of fertilizers to a mixture of peat moss and black peat in equal volumes to which 10 vol % farmyard manure of two sources were added. The mixtures of farmyard manure from both sources were studied, containing four increasing applications of phosphate, four increasing applications of lime, four increasing applications of dried blood, four increasing applications of urea. Furthermore mixtures with and without molybdate, and with and without copper slag. This series also included some commercial potting soils and two potting mixtures of four parts by volume of frozen black peat and 1 part by volume peat moss to which were added 10 vol % farmyard manure of both sources, fertilizers and 1% by weight of CMC.

At the beginning of September four plates of blocks were made from each mixture and used for pricking out lettuce of the Proeftuin's Blackpool variety. The plant bed lay in a frame on which no Dutch lights were laid, because of the hot and dry weather.

On 18th September plants in 42 mixtures were also planted out in 4-fold in an unheated Dutch light structure on a sandy soil. The plants of the commercial potting soils not included in the cultivation experiment.

To estimate the correlation between plant size at the time of planting out and the yield, both the size was assessed and the fresh weight of the aerial parts of eight plants in each replicate at planting out time.

Series F.

Two potting mixtures were included in this series, viz. PS and PT. They were distributed to growers to compare them with potting soils normally used in practice.

The basic composition of PS was a mixture of equal parts by volume of peat moss and black peat. To this mixture were added 100 l per m^3 of farmyard manure, 4 kg of dolomite lime with 20% MgO, 2 kg dicalcium phosphate, 250 g of urea, 500 g of copper slag and 5 g of ammonium molybdate. PT had the same composition, with the exception that 500 g of urea were added instead of 250 g of urea. PS was recommended for raising lettuce, PT for raising tomatoes. In some cases PS was used for tomatoes and PT for lettuce.

Series G.

This series included 60 potting mixtures made in November 1959. It included three commercial potting soils, the best mixtures from series B and C, a potting mixture on base of frozen black peat and four mixtures of black peat and peat moss in different proportions. There were also included mixtures of equal parts by volume of black peat and peat moss, to which were added three types of sand, viz. dune sand, river sand and silver sand in three quantities: 0, 10 and 20 vol %. Furthermore two sources of peat moss were compared and also four lots of black peat of the same origin but dug at different times. There were also studied four increasing applications of lime and four increasing applications of nitrogen with mixtures to which were added fertilizers with 10 vol % farmyard manure from two sources. In mid-November Mayqueen lettuce was pricked out in 4-fold. Later on the lettuce was planted out, i.e. plants of all 60 mixtures in 4-fold, in an unheated Dutch light structure on a sandy soil. Shortly after planting out, the lettuce was severely damaged by frost, and this may have influenced the correlation between plant size and yield. Victory tomatoes were pricked out in 4-fold at the end of December. In the beginning of February the tomatoes were planted out in a heated Dutch light structure on a sandy loam. As there was no more room, only three replicates instead of the four of plants of 60 mixtures could be planted out. One replicate was omitted. The yield from the first 14 pickings was noted, this giving $^1/_2$ to $^2/_3$ of the total yield.

Series H.

This series included 20 potting mixtures made at the beginning of September 1959. To make 16 mixtures there was first made one large heap of equal parts by volume of black peat and peat moss to which was added per m^3: 4 kg of dolomite lime, 2 kg of dicalcium phosphate, 500 g of copper slag, 10 g of sodium molybdate, 10 g of borax and 500 g sulphate of potash. The four other mixtures of this series had the same composition, except that 500 g sulphate of potash was omitted and replaced by 10 vol % farmyard manure from four sources.

The large heap was divided up into separate mixtures by increasing additions of three nitrogen fertilizers, viz. calcium nitrate, ammonium nitrate or urea and of four increasing additions of a NPK fertilizer (Crescal).

In mid-September lettuce of Proeftuin's Blackpool variety was pricked out in 4-fold (only 20 blocks to each plate), with Victory tomatoes also in 4-fold (12 blocks to each plate). Lettuce was raised on a plant bed in an unheated Dutch light structure, tomatoes were raised in a hothouse. At planting out stage the plants were visually evaluated for size, and the fresh weight of the aerial parts of the plants was determined.

Series I.

This series was started in order to study the application of micro-elements to a potting mixture of peat moss and black peat in equal parts by volume. In October 1959 7 mixtures were made by adding 4 sources of 10 vol % farmyard manure with fertilizers, by adding $7^1/_2$ vol % clay with fertilizers, by adding a NPK fertilizer, containing micro-elements (Poly-Crescal) and by adding a single fertilizer mixture.

Some days after pressing out soil blocks of the seven mixtures in 4-fold for lettuce and for tomatoes, micro-element solutions were poured over the blocks, 8 blocks at a time. Afterwards lettuce of Proeftuin's Blackpool variety and Victory tomatoes were pricked out. The plants were raised on benches in a hothouse. The size of the plants was visually evaluated and the fresh weight of the plants determined.

Series K.

This series is quite different from the others. This trial was started in order to study the influence of plant size on yield. About 100 plants from each nursery were collected from 81 groups of plants which had been pricked out into soil blocks. The 81 groups of plants were similar only in variety (Mayqueen). There were great differences in plant size. These differences cannot be attributed to the potting soil but are rather due to the method of raising and more especially to the date of pricking out. The correlation between data of pricking out and the plant size was $r = 0{,}63^{++}$.

20 plants were cut from each group and the fresh weight determined. After having been visually evaluated for size, the other plants of each group were subdivided into two groups and planted out, viz. in 2-fold. They were planted out mid-February in an unheated Dutch light structure on sandy soil.

Series L.

This series relates to a potting mixture made in the early spring of 1960. The mixture consisted of black peat and peat moss in equal parts by volume to which was added per m^3: 4 kg dolomite lime with 20% MgO, 2 kg dicalcium phosphate, 250 g copper slag, 500 g sulphate of potash, 350 g urea, 10 g borax and 5 g sodium molybdate. This mixture was distributed to 35 growers for raising tomatoes in order to compare it with the normally used potting soil.

Series M.

Soil blocks were made from the mixture of series L and Victory tomatoes pricked out. Five days after pricking out an emulsion of 2-methoxybenzonitril was poured on to the soil blocks, 3 sets of blocks at a time. This growth stimulator was diluted in glycerin and afterwards in water. Two weeks after the treatment the plants were cut and the fresh weight of the plants was determined.

Series N.

This series included potting mixtures with different ratios of black peat and peat moss, the latter of two sources, and of different ratios of black peat and frozen black peat. The ratios were 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 in parts by volume. This series also included two potting mixtures of two types of peat, which probably consisted of black peat with a percentage of less decomposed peat. To the mixtures fertilizers only were applied in the same composition and quantities as in series L.

Lettuce and tomatoes were pricked out in the first half of March 1960, both in 3-fold. Later the plant size was determined by weighing after cutting. Apart for these cultivation trials the potting mixtures were also used for an investigation into elasticity and pressure resistance (ROORDA VAN EYSINGA and MARTENS 1962) and for investigations by VAN DIJK. The object of the latter is to characterize peats and to find methods of analysing potting mixtures.

Series O.

This series included 35 potting mixtures made in March 1960. Except for three mixtures, viz. two commercial potting soils and a potting mixture made of frozen black peat to which were added fertilizers and 1% by weight of CMC, the series was started in order to study the optimal application of fertilizers to a mixture of equal parts by volume of black peat and peat moss. A comparison was made between four increasing applications of nitrogen, phosphate, molybdate and a NPK-fertilizer (Poly-Crescal). There were also mixtures with and without borax, with and without copper slag, with two sources of farmyard manure in 10 and 20 vol % and also with increasing applications of 2-methoxybenzonitril taken up in lime.

The potting mixtures were tested by growing strawberries, cauliflower, cucumbers and in some cases tomatoes.

Strawberries of the Talisman variety were pricked out in the beginning of April in 3-fold. (i.e. 3 × 18, or a total of 54 plants). At the end of April their size was visually evaluated.

Cauliflower of the Lecerf variety was pricked out in 3-fold at the end of March On pricking out the planting hole was not filled with dry sand but only closed by finger pressure. After visual evaluation, plants of 32 mixtures were planted out on 21th April to estimate the yield. The two trade potting soils and the frozen black peat mixture were omitted.

Cucumbers of the Bugrostan variety were pricked out in 3-fold in mid-April. Each replicate had 3 plates (= 18 soil blocks). At the beginning of May the plant size was visually evaluated. Plants of 12 potting mixtures were planted out in 3-fold in a Dutch light structure on a sandy soil. Eighteen plants being available for each replicate, only the 12 most uniform plants were selected of each mixture. The 12 potting mixtures were so selected that tall, small and middle-sized plants were in the same proportion. As many plants died, the record of yield was finished after eight pickings.

With tomatoes of the Victory variety, some of the potting mixtures were used to study the optimal nitrogen application on plants differing in size at planting out time. Two groups of plants, one group of seedlings and the other of an older plant which had already been pricked out in a tray, were pricked out into blocks on plates with 16 blocks on each plate in 4-fold on the 30th of March. This trial included the potting mixtures with four increasing applications of nitrogen and of Poly-Crescal and the four mixtures with different sources and quantities of farmyard manure. After four weeks the plants were visually evaluated and the fresh weight was determined after cutting.

Series P.

The investigations led to a subsidiary experiment in which strawberries were cultivated in soil blocks. The cultivation of strawberries under glass in the north-Limburg region was introduced vid. this experiment.

Series P deals with a potting mixture used for strawberry cultivation. This mixture, of equal parts by volume of black peat and peat moss to which was added per m^3: 4 kg of dolomite lime, 2 kg of dicalcium phosphate, 1 kg of Poly-Crescal and 4 g of sodium molybdate, was made in July 1960. A part of the potting mixture was distributed to growers to prick out strawberries, which were later planted out.

Strawberry runner plants of the Regina variety were pricked out into soil blocks at the Venlo Experiment Station at the beginning of August. These plants were forced in a heated glasshouse, with the use of artificial light, starting at the beginning of January 1961. Boxes were normally used for this culture.

Series Q.

This series included potting mixtures with different ratios of black peat and peat moss, the latter of two origins, and with different ratios of black peat and frozen black peat. The mixtures were made in July 1960, the ratios being 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100 in parts by volume. The mixtures were made with fertilizers only or with 10 vol % of farmyard manure and fertilizers. Lettuce of the Proeftuin's Blackpool variety was pricked out in 6-fold at the beginning of August. Of the six replicates, three received no water and three replicates were regularly watered. At the planting-out stage the plants were visually evaluated and the fresh weight determined.

Series R.

This series was started in order to study the effect of applying insecticides. First a large heap of a mixture of equal parts of black peat and peat moss was made to which was added per m^3: 4 kg of dolomite lime, 2 kg of dicalcium phosphate, 1 kg of Poly-Crescal and 5 g of sodium molybdate. Then there was mixed again a. with no addition b. with application of aldrin, 25% dust per m^3 and c. with application of 250 cm^3 of heptachlor 25% emulsion per m^3. Lettuce of the Proeftuin's Blackpool variety, cauliflower of unknown variety and tomatoes of the Dwarf Gem variety (48 plants each replicate) were pricked out in 2-fold in mid-August. The fresh weight of the plants was determined at planting out stage after cutting.

Series S.

This series included 21 potting mixtures with equal parts by volume of black peat and peat moss with an application of 2 kg of dicalcium phosphate, 1 kg of Poly-Crescal and 5 g of sodium molybdate per m^3. The objects of investigations were: three increasing applications of dune sand viz. 0, 10 and 20 vol % in all cases with: no lime; three increasing applications of Dolokal supra (1, 2 and 4 kg per m^3) and three increasing applications (1, 2 and 4 kg per m^3) of a mixture of Dolokal supra and Kencica (fifty-fifty by weight).

Lettuce of the Proeftuin's Blackpool variety was pricked out in 6-fold in the beginning of September. After visual judgement of plant size the lettuce was planted out in an unheated Dutch light structure on a sandy soil to estimate yield.

Series T.

This series included seven potting mixtures (6 in the case of cucumber). First a large heap was made of a mixture of equal parts by volume of black peat and peat moss with the applicataion of 4 kg of dolomite lime, 2 kg of dicalcium phosphate, 500 g of copper slag, 350 g of urea and 5 g of sodium molybdate per m^3. This was again mixed with 0, 100, 200, 400, 800, and 1600 g sulphate of potash per m^3. For lettuce and tomatoes the 0 K-mixture was made twice.

Lettuce of the Proeftuin's Blackpool variety in 3-fold, tomatoes of the Victory variety in 3-fold and cucumbers of the Bugrostan variety in 2-fold were pricked out at the beginning of November 1960. At planting out stage the fresh weight of the plants was determined after cutting.

Series U.

This series included 24 potting mixtures, in all cases made with 4 increasing applications of silver sand and with 6 different ratios of black peat and peat moss. The applications of silver sand were 0, 7.5, 15 and 30 vol %. The ratios of black peat and peat moss were 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100. All mixtures were given

3.5 kg of dolomite lime, 500 g of Kencica, 2 kg of dicalcium phosphate, 1 kg of Poly-Crescal and 5 g of sodium molybdate per m^3. Cucumbers of the Groene Standaard variety in 3-fold and Victory tomatoes in 6-fold were pricked out in December 1960. In the case of tomatoes three replicates were placed on a bench of reed mats and three on a bench on plastic sheets. At the planting-out stage the fresh weight of the plants was determined after cutting.

Later Mayqueen lettuce was pricked out in 7-fold. After visual evaluation of plant size they were planted out in an unheated Dutch light structure on a sandy soil in mid-January. The lettuce was harvested at the end of March and the yield then recorded.

Series V.

This series included eight potting mixtures made at the end of December 1960. By error eleven instead of ten parts by volume of black peat and nine instead of ten parts by volume of peat moss were mixed. To this mixture per m^3 were applied: 1 kg Kencica, 2 kg dicalcium phosphate, 1 kg Poly-Crescal, 5 g sodium molybdate and the 8 objects studied, viz.:

a 3000 g calcium and 0 g magnesium carbonate
b 2000 g calcium and 715 g magnesium carbonate
c 1000 g calcium and 1430 g magnesium carbonate
d 0 g calcium and 2145 g magnesium carbonate
e 0 kg kieserite and 3 kg calcium carbonate
f 1 kg kieserite and 3 kg calcium carbonate
g 2 kg kieserite and 3 kg calcium carbonate
h 4 kg kieserite and 3 kg calcium carbonate

Lettuce of the Proeftuin's Blackpool variety, Victory tomatoes and cucumbers of the Groene Standaard variety were pricked out in 4-fold at the beginning of January. At the planting-out stage plants were cut and the fresh weight determined.

Series W.

This series, including 20 potting mixtures with five different ratios of black peat and peat moss, the latter of two origins, were made in mid-February 1961. The different ratios of one of the sources of peat moss ("Zwolle"), were in all cases studied with three increasing applications of silver sand namely 0, 15 and 30 vol %. The ratios of black peat and peat moss were equal for both origins of peat moss and were 100:0, 75:25, 50:50, 25:75 and 0:100 by volume. 3 kg of dolomite lime, 1 kg of Kencica, 2 kg of dicalcium phosphate, 1 kg of Poly-Crescal and 5 g of sodium molybdate were applied per m^3. Cucumbers, probably of the Groene Standaard variety, were pricked out in 4-fold. At the planting-out stage the fresh weight of the plants was determined after cutting.

The mixtures were also used for investigating the change of volume of peat blocks on drying (ROORDA VAN EYSINGA en MARTENS 1963) and for an investigation by VAN DIJK (see also under series N).

Series X.

Potting mixtures that have been kept outside for some length of time and contain a high percentage of peat sometimes show a nitrogen deficiency. An experiment was therefore started to find whether nitrogen is lost by leaching or fixation. The potting mixtures in this series were exactly equal in composition, being equal parts by volume of black peat and peat moss to which was added 3 kg of dolomite lime, 1 kg of Kencica, 2 kg of dicalcium phosphate, $1^1/_4$ kg of Poly-Crescal and 5 g of sodium molybdate per m^3. The only difference was in the date of manufacture. The potting mixtures were stored out-of-doors in plastic baskets. The early spring of 1961, when the baskets were out of doors, was extremely wet. No crop was cultivated. Nitrogen content was at one point estimated in samples from different layers from two baskets.

Series Y.

This series included 8 potting mixtures made in May 1961. First one mixture was made of equal parts by volume of black peat and peat moss with the addition of 3 kg of dolomite lime, 1 kg of Kencica, 2 kg of dicalcium phosphate, $1^1/_4$ kg of Crescal and 5 g of sodium molybdate per m^3 of the mixture. The mixture was divided into two parts and to one part 10 vol % farmyard manure was added. The two parts were again subdivided with addition of potassium bichromate ($K_2Cr_2O_7$) in quantities of 0, $2^1/_2$, 5 and 10 g per m^3.

In mid-May cucumbers, probably of the Groene Standaard variety, were pricked out in 3-fold into soil blocks and clay pots. The average fresh weight of the soil blocks was 1275 g, and the clay pots held an average fresh weight of 675 g. The moisture content of the soils were much the same, viz. 544 g of moisture per 100 g of dried soil of the blocks and 533 g of moisture per 100 g of dried soil of the clay pots.

The fresh weight of the plants cut was determined two weeks after pricking out.

Series Z.

This series was made in July 1961 and included 24 potting mixtures. First one mixture was made of equal parts by volume of black peat and peat moss with addition of 2.25 kg of dolomite lime, 1 kg of Kencica, 2 kg of dicalcium phosphate, 1.25 kg of Crescal and 5 g of sodium molybdate per m^3. The mixture was subdivided into 24 mixtures to which were added 750 g of dolomite lime per m^3 and also the growth stimulators α-naphtoicacid 0, 0.5, 1, 5, 10 and 50 g per m^3; 1-hydroxy naphtoicacid 0, 0.5, 1, 5, 10, 50 and 100 g per m^3 and 2-methoxybenzonitril 0, 0.5, 1, 2 and 4 cm^3 per m^3 and the insecticide heptachlor 25% emulsion 0, 10, 25, 100, 250 and 500 cm^3 per m^3. The 2-methoxybenzonitril was taken up in the dolomite lime. Lettuce of the Wonder van Feltham variety was pricked out in 3-fold at the beginning of August. At the planting-out stage the fresh weight of the plants was determined after cutting.

Series AA.

This series, including 10 potting mixtures with increasing applications of nitrogen and 24 potting mixtures to which were added growth stimulators and one insecticide, was made July 1961. In order to make potting mixtures with increasing percentages of nitrogen there was first made a mixture of equal parts by volume of black peat and peat moss with the application of 3 kg of dolomite lime, 1 kg of Kencica, 2 kg of dicalcium phosphate and 250 g of sulphate of potash per m^3. This was again mixed with application of 0, 150, 300 and 600 g N per m^3. Nitrogen was applied in the form of nitro-chalk, Floranid and a mixture of both, the ratio being fifty-fifty based on the N-content. Strawberries of the Regina variety were pricked out in 6-fold at the end of July.

In order to make the other mixtures, one mixture was first made of equal parts by volume of black peat and peat moss with application of 2,4 kg of dolomite lime, 1 kg of Kencica, 2 kg of dicalcium phosphate, 1 kg of Crescal, 500 g of nitro-chalk and 500 g of Floranid per m^3. The growth stimulators and the insecticide to be studied were the same as in series Z. For this series only 600 g dolomite lime instead of 750 g per m^3 as in series Z was applied on subdivision and second mixing. For the latter mixtures strawberries of the Deutsch Evern variety were pricked out in 3-fold at the end of July.

The strawberries were evaluated for plant size at the end of August. Afterwards the plants were used for forcing with heat and artificial light, no further records being made.