Chemical and Physical Properties of Mineral Soils Ameliorated with "Horticultural Peat"

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ABSTRACT

In Dutch horticulture older raised-bog peat, frozen in the raw (fresh) condition and termed "horticultural peat" is much used for potting soils and for the amelioration of mineral soils.

This peat temporarily fixes some nitrogen, but not in quantities interfering with crop growth. Its rate of decomposition is comparable with that of organic matter in mineral soils.

Mixed through the peat, phosphate is protected against fixation in the soil. The peat even mobilizes soil phosphate.

The availability of potassium is not significantly influenced.

After liming the pH initially rises and then gradually decreases somewhat. Liming stimulates the decomposition of the peat.

When the soil is to be used for vegetable growing, about 0.35 kg N, at least 1.2 kg P_2O_5, 0.45 kg K_2O and about 4 kg $CaCO_3$ must be added per m_3 of loose, moist peat.

The physical properties of mineral soils are generally significantly improved by admixing horticultural peat. After a few years, however, the effect recedes somewhat.

RÉSUMÉ

L'horticulture hollandaise utilise fréquemment de la "tourbe horticole", tourbe fortement décomposée après son exposition au gel à l'état humide, comme amendement des sols et comme principal composant dans la préparation du terreau.

La tourbe fixe, temporairement, un certain pourcentage d'azote sans que le développement des plantes en soit dérangé. La vitesse de décomposition est sensiblement égale à celle de la matière organique des sols minéraux.

Les phosphates mélangés à cette tourbe se trouvent protégés de la fixation au sol. La tourbe absorbe même les phosphates du sol.

La tourbe horticole n'immobilise pas la potasse sous forme d'élément assimilable par les plantes.

Après le chaulage le pH diminue graduellement.

Le chaulage active la décomposition de la tourbe.

Pour les cultures maraîchères il est nécessaire d'ajouter environ 0.35 kg N, au moins 1.2 kg P_2O_5, 0.45 kg K_2O et à peu près 4 kg $CaCO_3$ au mètre cube de tourbe humide et dégagée.

La tourbe horticole améliore les propriétés physiques des sols minéraux. Après quelques années l'effet s'atténue cependant quelque peu.

INTRODUCTION

In The Netherlands in 1967 as much as 200,000 m^3 of horticultural peat were produced. This refers to humified raised-bog peat (von Post scale, about seven), which is cut in the autumn and exposed to frost during the winter. It is shredded or milled after drying to a moisture content of about 70 to 80 per cent. The greater proportion is used for the manufacture of potting soils. However, with the growing practice of horticulture this peat is also used more and more for the amelioration of light sandy soils as well as heavy clay soils.

In this paper the interactions between peat and plant nutrients — nitrogen (N), phosphorus (P), potassium (K), and lime (Ca) —are treated. In addition, some data are given showing the extent of the physical improvement of mineral soils.

INTERACTION BETWEEN PEAT AND PLANT NUTRIENTS, ESPECIALLY NITROGEN

Horticultural peat is very poor in plant nutrients. Reeker (1962) mentions 0.8 - 1.2 per cent N, 0.025 - 0.10 per cent P_2O_5, and 0.03 - 0.05 per cent K_2O, calculated on the dry matter basis. The availability also of these nutrients for plant growth is low.

In respect to the efficiency of fertilizers, it is important to know whether the peat will fix part of the added nutrients. (The organic matter content of peat is about 93 per cent of the dry matter; the C/N-ratio is 50 - 60.) On the other hand, it might also be possible that the acid peat (pH-H_2O between 3.2 and

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4.4) mobilizes nutrients present in the mineral soil in an originally unavailable form for plants. Also, it is interesting to know what is the influence of fertilizing on the peat itself in the mixture with soil.

Nitrogen

Many investigations have been made concerned with nitrogen fixation by peat. It is a well established fact that under extreme conditions of pH, NH_3 concentration, temperature and pressure (especially of oxygen) much nitrogen can be fixed, and partly in a form in which it is practically unavailable for plants. Several authors stated that also under more normal conditions a substantial amount of nitrogen can be fixed by peat in a form in which it cannot be extracted with water or salt solutions (e.g., Duchaufour and Mangenot, 1956; Broadbent *et al.,* 1960; Nõmmik and Nilsson, 1963; and Wieringa, 1963).

On the other hand, Kivinen *et al.* (1954), Kivinen and Kaila (1958), Von Zezschwitz (1956a) and others showed in incubation and pot experiments that even peat with a low nitrogen content can act as a source of nitrogen because of mineralization of the organic nitrogen. Therefore, experiments to establish the optimum level of nitrogen fertilization when using horticultural peat did not seem to be superfluous.

Incubation Experiment

Horticultural peat (organic matter content 98.1 per cent; total nitrogen (N_t) 1.01 per cent; pH-H_2O 3.65) was intimately mixed with ammonium nitrate in four different concentrations and with potassium and phosphate fertilizers. Then this fertilized peat was thoroughly mixed with a river-clay soil (organic matter 2.6 per cent; N_t 0.09 per cent; pH-H_2O 7.74, $CaCO_3$ 3.7 per cent; clay content ($<2\mu$) 23.6 per cent) in a ratio clay : peat of 1:0, 4:1, 3:1, and 2:1. The clay soil without peat admixture was also fertilized with ammonium nitrate in four levels.

The 16 mixtures obtained were well-aerated and, with, a water content corresponding to 60 per cent of their water-capacity, were incubated at 29°C during a period of 32 weeks. At regular intervals the CO_2 evolution resulting from microbial degradation and the level of mineral nitrogen was determined; the latter by a single extraction of an amount of the moist mixture with 1N NaCl solution in a ratio of 200 g:500 ml. The results are summarized in Table I.

TABLE I

Fixation of Mineral Nitrogen by Horticultural Peat (and Decomposition of Peat) in Mixtures with a Clay Soil (Laboratory Experiment)

clay + peat (vol.)	min. N added* (ppm)	Recovery of mineral N in percentage of N added after incubation at 29°C, during........weeks** 0	1	2	4	8	16	32	Percentage of Carbon miner-alized***
1+0	0								10.0
	108	87	87	94	91	85	62	40	9.4
	216	89	100	95	–	94	72	50	8.8
	324	90	90	96	101	96	62	58	8.1
		89	92	95	96	92	65	49	average
4+1	0								(18.9)
	115	76	83	79	93	83	75	52	(14.1)
	230	80	87	83	97	92	77	43	(7.7)
	345	83	81	86	88	94	73	63	(8.2)
		80	83	83	93	90	75	53	average
3+1	0								(16.4)
	152	78	86	84	94	92	83	67	(12.6)
	304	81	80	83	99	98	89	–	(7.0)
	456	82	80	89	98	103	91	75	(7.0)
		80	82	85	97	98	88	71	average
2+1	0								(14.2)
	224	87	80	87	94	97	80	50	(7.6)
	448	85	80	87	95	106	89	61	(6.6)
	672	85	77	86	94	103	93	64	(7.6)
		86	79	87	94	102	87	58	average

*As NH_4NO_3

**The amount of mineral nitrogen in the flasks where no NH_4NO_3 was added, was taken as a correction.

***Percentage of soil organic carbon and of peat-carbon (figures between parentheses), converted into CO_2 during 32 weeks of incubation.

It was found that in general the recovery of mineral nitrogen as a percentage of the added nitrogen was about the same for all 16 mixtures. However, there was no definite influence of the nitrogen level nor of the amount of peat admixed; therefore, there seems to be no significant specific fixation of mineral nitrogen by the peat as an overall effect.

Other experiments showed that the apparent "loss" of mineral nitrogen at the start (after --- weeks) may be attributed for the most part to an incomplete extraction, particularly of ammonium nitrogen. The increase of the mineral nitrogen level in the first eight weeks can, at least partly, be attributed to the fact that the ammonium ions are converted into nitrate which is more readily extractable from soil.

After eight weeks a remarkable decrease of the mineral nitrogen level in all mixtures as well as in the soil without peat becomes evident. Besides possible fixation, this might also be due to a loss of mineral nitrogen through denitrification, although this is not very probable since the aeration was sufficient.

The last column of Table I gives the percentages of soil organic carbon and, for the soil-peat mixtures, the percentages of peat-carbon, converted into CO_2. To calculate the latter percentages it was assumed that the decomposition of peat to CO_2 depends on the mineral nitrogen level in the same way as the organic matter in the original soil. Furthermore, it was assumed that the rate of decomposition of the latter is the same in the mixtures with peat as in the soil without peat. Neither of these assumptions, however, may be quite true. From the data thus calculated it is found that fertilization with nitrogen clearly inhibits the breakdown of the organic matter into CO_2 This phenomenon was observed also with other soils and materials. A second important conclusion is that the rate of decomposition of this peat is of the same order of magnitude as that of the organic matter in mineral soils, notwithstanding the wide C/N ratio of the peat.

From this point of view, large-scale microbial fixation of mineral nitrogen need not be expected.

Figure 1 shows the course of the CO_2 production of some mixtures and of the original soil with and without a nitrogen dressing. It can be observed that only in the first weeks the CO_2 production is stimulated by the addition of ammonium nitrate; in the long run, however, this production is strongly inhibited. It is worth noticing that the curves for the mixtures, even after 32 weeks, still do not tend to level off. The disappearance of the most easily decomposed organic compounds from the peat seems to be counterbalanced by an adaptation of the micro-flora to the decomposition of remaining compounds.

Pot Experiments

An investigation of the optimal nitrogen fertilization for the cultivation of vegetables in view of an eventual fixation of nitrogen by the peat was carried out in two pot experiments with four consecutive crops of lettuce and endive.

Samples of horticultural peat were thoroughly mixed with ammonium nitrate in six different levels. Different amounts of

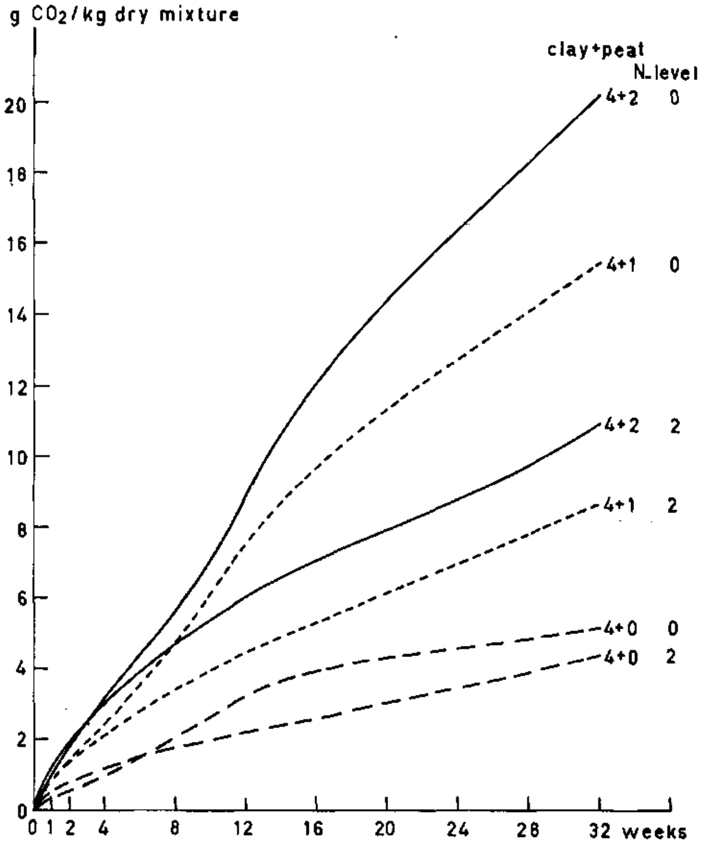


Figure 1. Influence on CO_2 production of mixing horticultural peat and nitrogen fertilizer with a clay soil.

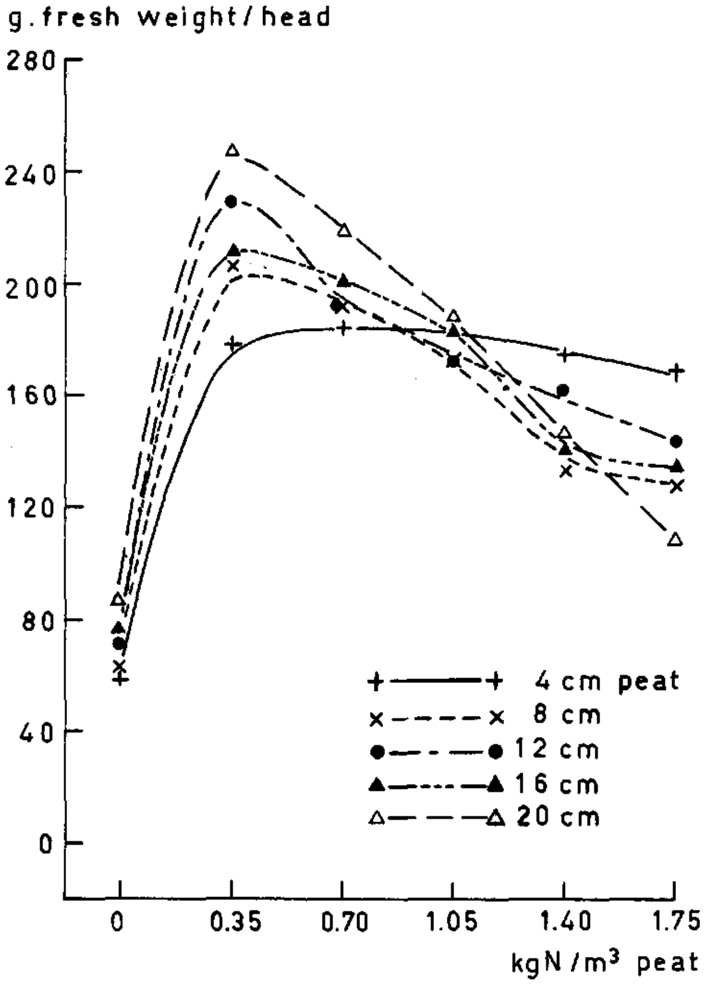


Figure 2. Yield of lettuce on a clay soil mixed with different amounts of horticultural peat (the latter enriched with different amounts of ammonium nitrate).

these mixtures were added to a sandy soil and to a heavy river-clay soil, corresponding to an application of layers of 0, 4, 8, 12, 16 and 20 cm depth of peat, respectively on a topsoil of 18 cm. Soil and peat were then thoroughly mixed and the pots were filled.

The results of the experiment with clay-soil are shown in Figure 2. The results with sandy soil were comparable. Firstly, the yields of lettuce and endive correlated with the amounts of peat applied. Secondly, for lettuce, which was the first crop, the optimal addition of nitrogen was 0.35 kg N/m^3 of peat (except in the case where 4 cm peat were used in the experiment with clay-soil). For endive, the second crop, this optimum was 0.70 kg, but it must be taken into account that in this case no compensation was made for the nitrogen taken up by the lettuce. Thirdly, beyond the optimal nitrogen addition, the yield strongly decreased.

After each of the four crops were grown consecutively on the clay and peat mixtures in a period of 10 months, soil samples were analyzed for mineral nitrogen, organic carbon and nitrogen, and hydrolyzability of the latter. After removal of the interfering nitrate by washing with water, the samples were treated with 80 per cent cold sulphuric acid followed by boiling after dilution to 4 per cent. After these 10 months the pots were kept fallow and about every six months soil samples were analyzed. After 16 months the soil in the pots was top-dressed with urea in proportion to the peat content, and the soil again periodically analyzed.

Part of the analytical data are given in Table II. The data of the pots with 0, 4, and 8 cm of peat are omitted, as here the level of mineral nitrogen had no effect, neither on the content of organic nitrogen, nor on non-hydrolyzable nitrogen, nor on the C/N ratio. Only the data of the pots with 12, 16, and 20 cm of peat (10.0, 15.2, and 22.5 per cent organic matter, respectively) are given.

These data show a significant increase in the percentage of organic nitrogen with the level of mineral nitrogen as well as with time. Correspondingly, there is a decrease of the C/N ratio. A similar decrease is also observed when the sandy sub-soil of raised-bog peats, left after cutting of the peat, is reclaimed using cut-over peat.

The more peat was admixed, the higher was the percentage increase of organic nitrogen. This proves that the binding of nitrogen may not be attributed to crop residues but mainly to the peat.

There is an indication of an increase in non-hydrolyzable nitrogen in the pots with 16 and 20 cm peat only, when after 26 months an additional amount of nitrogen in the form of urea is supplied. Thus, the gradually "fixed" mineral nitrogen is found mainly as hydrolyzable organic compounds. In agreement with this the more nitrogen remineralized on incubation the more mineral nitrogen had been fixed, (see last column of Table III).

The increase of organic nitrogen with the increase in concentration of mineral nitrogen seems to contradict the results of the incubation experiment of the foregoing section where mineral nitrogen appeared to inhibit the CO_2 production. A possible explanation is that the breakdown of organic matter to CO_2 is inhibited, but that the microbial activity is nevertheless

TABLE II
Fixation of Mineral Nitrogen by Horticultural Peat in Mixtures with a Clay Soil (Pot Experiment)
(m = months)

Per cent org. matter (C/N org.)	min. N at start (ppm)*	Org. N (per cent) after			Added urea-N (per cent)	Org. N (per cent) after another		non-hydrolyzable org. N (per cent) after		non-hydrolyzable org. N (per cent) after another		C/N org. after		N-mineralization** (ppm)
		10 m	16 m	26 m		4 m	8 m	16 m	26 m	4 m	8 m	26 m	26+8 m	
10.0	23	0.20	0.20	0.21	(0.11)	0.23	0.24	0.10	0.09	0.10	0.10	24	22	31
(29)	280	0.18	0.20	0.21	(0.09)	0.23	0.23	0.10	0.10	0.10	0.10	23	22	–
	890	0.18	0.22	0.22	(0.09)	0.22	0.24	0.10	0.11	0.10	0.10	23	22	–
	1260	0.20	0.24	0.24	(0.10)	0.24	0.25	0.10	0.10	0.10	0.10	22	22	51
15.2	210	0.24	0.26	0.26	(0.19)	0.30	0.33	0.13	0.13	0.13	0.14	28	24	–
(33)	410	0.26	0.26	0.29	(0.18)	0.32	0.32	0.13	0.14	0.14	0.15	28	25	–
	1400	0.26	0.28	0.29	(0.18)	0.32	0.34	0.13	0.13	0.15	0.17	27	25	–
	1900	0.29	0.30	0.31	(0.18)	0.35	0.36	0.14	0.14	0.16	0.20	25	24	70
22.5	50	0.34	0.36	0.36	(0.21)	0.42	0.48	0.20	0.18	0.22	0.22	32	26	98
(34)	910	0.38	0.38	0.36	(0.21)	0.48	0.50	0.20	0.20	0.22	0.22	33	24	–
	2510	0.36	0.42	0.42	(0.22)	0.44	0.52	0.18	0.21	0.22	0.24	28	26	–
	ca.3500	0.40	0.47	0.46	(0.20)	0.50	0.51	0.20	0.22	0.22	0.26	25	27	108

*About half as ammonium-N, half as nitrate-N.
**Nitrogen mineralized during 6 weeks of incubation at 29°C, in samples taken after 26+8 months and washed with water to remove most of the mineral nitrogen.

TABLE III
Influence of Method of Applying Triple-superphosphate on the Production of Lettuce and Endive and on the Uptake of Phosphate

	g fresh weight/head		mg P_2O_5/plant	
	lettuce	endive	lettuce	endive
Mixing phosphate with peat then mixing with the soil	128	160	62	115
Mixing peat, phosphate and soil all at once	51	151	25	81
Mixing phosphate with the soil, then mixing with peat	40	132	19	66

stimulated by nitrogen, leading to an enhanced resynthesis of nitrogen enriched "humus".

Another possibility would be a fixation of mineral nitrogen mainly as a chemical process. As, however, all the ammonium and urea nitrogen in these mixtures appeared to be converted into nitrate within a very short time, this hypothesis seems less probable.

The results of the plant analyses of lettuce and endive indicate that the "fixation" is only a temporary one, not interfering seriously with the uptake of nitrogen by the plants. The sum total of the nitrogen taken up by the four successive crops and the remaining mineral nitrogen in the pots is in most cases nearly equal to the original amount of mineral nitrogen. There are even indications that this nitrogen-poor peat can supply some nitrogen through mineralization.

The final conclusion is that horticultural peat under normal culture conditions exhibits no serious fixation of mineral nitrogen. However, to estimate the need of nitrogenous fertilization it should be taken into account that a fresh mixture of soil and peat will mineralize less nitrogen than on old "ripe" garden soil with a comparable organic matter content.

Phosphate

As stated, horticultural peat has a low phosphorus content and this phosphorus is not considered readily available for plants. Applying much of this peat, therefore, might necessitate an extra addition of phosphate. An experiment with a sandy soil, previously used for agriculture, however, gave quite a different result (Figure 3).

For the soil alone, an addition of 480 kg P_2O_5/ha was still not optimal for lettuce. (P-water of this soil was 0; P-ammonium lactate was 18.) When the applied triple super-phosphate was thoroughly mixed with the peat and thereafter roughly mixed with the topsoil, much better results were achieved with less phosphate. When applying 4 cm peat to the soil, at least 1.2 kg P_2O_5 must be mixed with one m^3 of loose moist peat.

This surprising result must be attributed mainly to protection of the phosphate against fixation in the soil when mixed with the peat. This was illustrated by another experiment where the phosphate was applied in three ways, firstly, as above, i.e., mixing it with the peat and then with the topsoil; secondly, spreading it on the soil followed by covering it with a layer of peat and then working both through the topsoil; thirdly, mixing the phosphate with the topsoil and then applying the peat. The results (Table III) show in this order a decreasing crop yield and uptake of phosphate by the crop, which must be caused primarily by an increasing fixation of the phosphate in the soil.

As to the question of whether the peat binds or releases phosphate, the data from the non-phosphate plots give information (Table IV). It is found that at pH-KCl 4.6, addition of peat to the soil slightly enhances the solubility of phosphate in water. Raising the pH to 5.0 by liming, reduced this increase of phosphate solubility in water to almost zero. In both cases, however, the phosphate uptake by the crop is clearly enhanced, and in direct relation to the amount of peat that was admixed.

Two pot experiments, one performed by van der Paauw (personal communication), clearly corroborated that adding horticultural peat brings about an increase in the availability of the soil phosphate. Therefore, the peat acts as a phosphate fertilizer but to prevent an exhaustion of the phosphate resources of the soil fertilizer phosphate must be added.

Potassium

The effect of horticultural peat on the availability of potassium was investigated in a pot experiment. When comparing pots with increasing amounts of peat but with the same additions of potas-

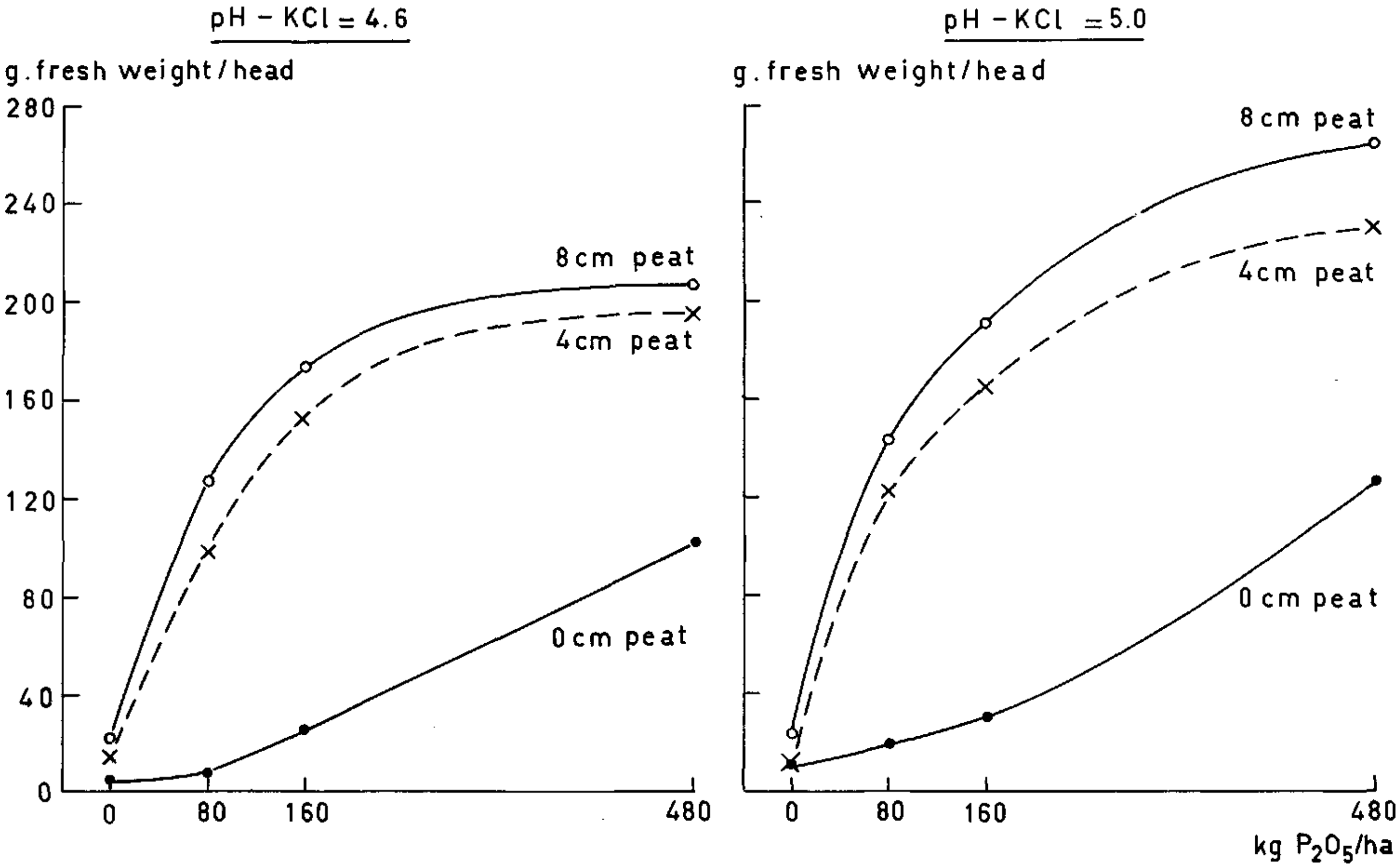


Figure 3. Influence on yield of lettuce to phosphate applied directly to the soil and mixed with horticultural peat and then applied to the soil (at two pH-levels).

TABLE IV
Influence of Horticultural Peat on the Availability of Soil Phosphate on the No-fertilizer Plots

cm of peat	P-water		P-amm.lact. (mg P_2O_5/100 g soil)		P-total (mg P_2O_5/100 g soil)		mg P_2O_5 taken up by the crop	
	pH-KCl 4.6	pH-KCl 5.0	pH 4.6	pH 5.0	pH 4.6	pH 5.0	pH 4.6	pH 5.0
0	0.5	0.7	22	28	50	50	48	79
4	1.2	0.8	23	25	50	50	57	86
8	1.3	1.4	22	21	50	50	76	108

sium-fertilizers per pot, the amount of potassium soluble in 0.1 N hydrochloric acid increased when calculated on a dry weight basis. This increase, however, has to be attributed to the decrease of the weight per unit volume of the soil by admixing peat. Calculation showed that the amount of available potassium per volume unit of soil-peat mixture had decreased. The same can be said for total potassium.

The question is whether the crop yield responds primarily to the concentration of available potassium in the topsoil as long as it is at a normal level, or to the amount present in a certain soil volume. Pot experiments designed to investigate this question gave no satisfactory answer because the highly increased availability of phosphate by the addition of peat brought about a higher crop yield and therefore a higher requirement for potassium. To maintain the total amount of potassium per unit volume of mixture, 0.45 kg K_2O/m^3 peat is necessary.

Chemically, it seems not very probable that the peat will fix potassium in a form not available for plants. From this point of view there are no objections to mix the potassium fertilizer through the peat before applying it to the soil. On potassium-fixing soils this procedure might even be more advantageous.

Liming

Horticultural peat has a very low (pH pH-H_2O 3.2 - 4.4; pH-KCl about 2 - 3). When large amounts of peat are added to the soil, liming may be necessary. The amount of lime required depends on the ion exchange capacity of the peat, which is primarily dependent on the state of dryness and secondarily on the nature and degree of decomposition of the peat. For example, the ion exchange capacity of raw, older raised-bog peat is about 160 m.e. per 100 g of dry matter, whereas after freezing and air-drying this value has decreased to about 70 m.e. In terms of the amount of lime per unit volume, this difference is partly compensated for by the fact that the volume weight of dry peat increases from approximately 100 for 1 m^3 raw peat to about 175 for 1 m^3 air-dry horticultural peat.

To raise the pH-KCl by about 3 units, i.e., to 5 - 6, about *4.0 kg $CaCO_3$ (2.2 kg CaO) are needed per m^3 moist horticultural* peat. (The relation between pH and amount of lime is nearly linear to pH-KCl 6.0.)

However, it is often observed that the pH of a mixture of soil and limed peat after some time decreases again. It is also a well established fact that liming of peat stimulates the microbial breakdown of the peat material (e.g., Frercks and Puffe, 1959,

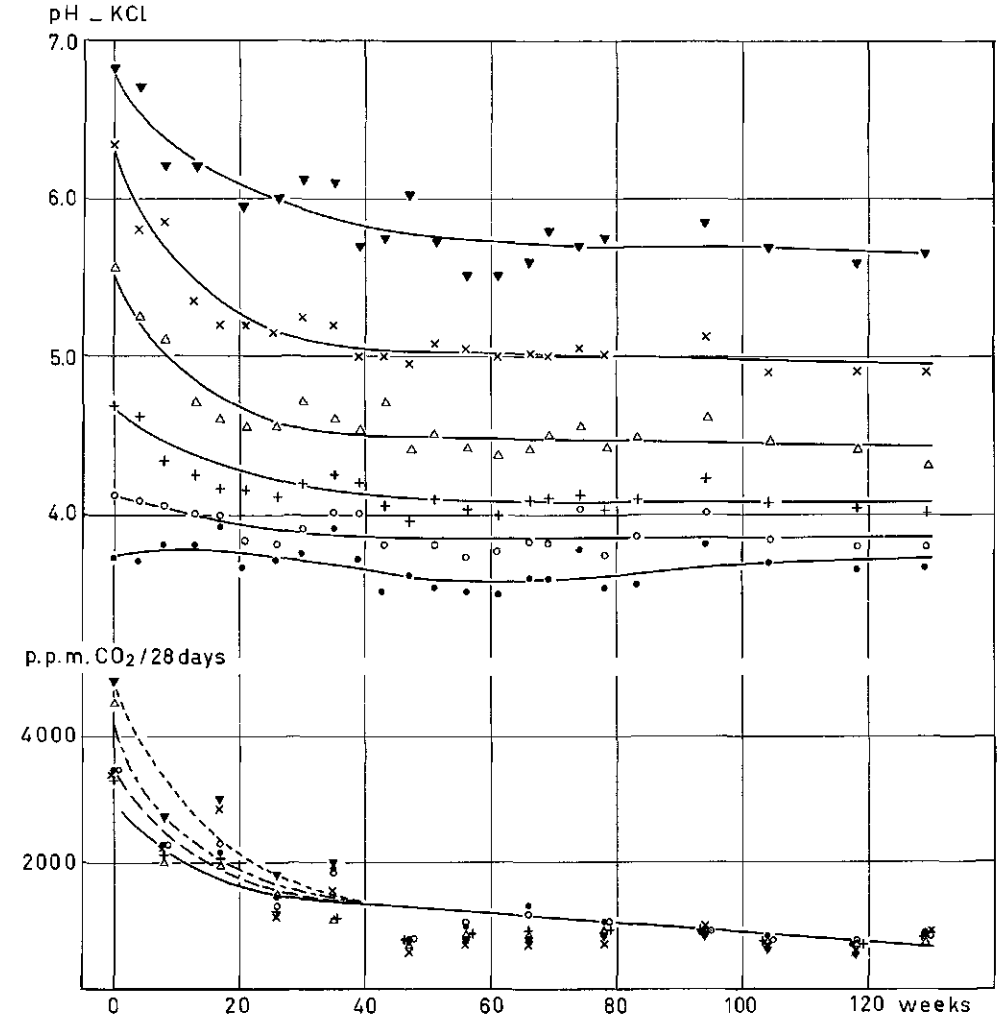


Figure 4. Influence of liming on the CO_2 production of a mixture of a sandy soil and horticultural peat.

Von Zezschwitz, 1956b), although this has not always been accompanied by a decrease of pH.

This point was checked for horticultural peat in a pot experiment with a sandy soil (pH-KCl 4.6) thoroughly mixed with 40 per cent by volume of peat. Six pH levels were established by liming. All pots received the same amount of other fertilizers, including trace elements, and were kept at a moisture content corresponding to 60 per cent of the water capacity. No crop was grown.

The changes of the pH during the experiment are shown in Figure 4. The 4th, 5th and 6th pH levels decreased by about 1.2 units in one year, the third level 0.5 unit and the second 0.25 unit. After one year the changes become insignificant.

In conclusion, one should either at the start establish a pH level about one unit higher than that ultimately desired or add more lime after one year to maintain a chosen pH level.

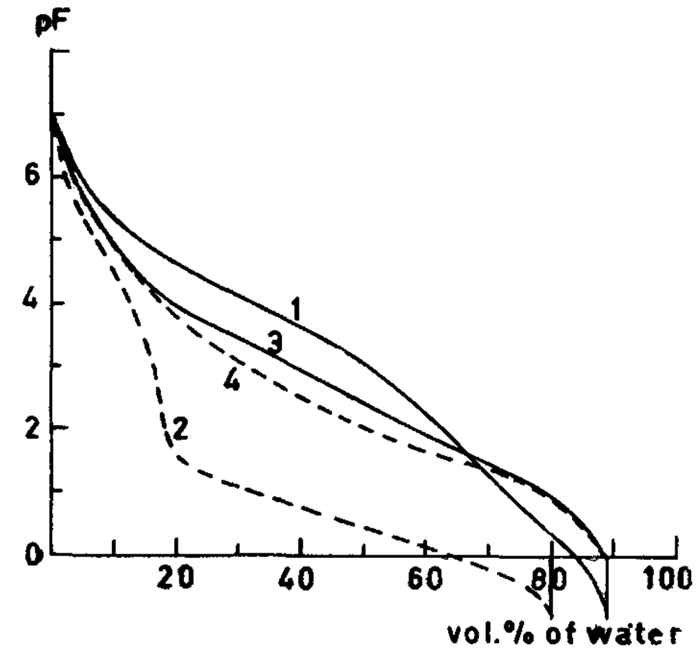
Figure 4 also shows the amounts of CO_2 produced by the samples taken at regular intervals and incubated during four weeks at 29°C in the laboratory. (As for the curve of the pH, smooth curves were drawn.) These curves indeed show a stimulation of the microbial activity upon liming during the first half-year. After that time, however, no further differences could be clearly observed.

From a considerable number of field experiments, Kortleven (1955) concluded that a rise in pH of one unit achieved by liming, led to an average decrease of 4 per cent of the initial value in the organic-matter content. As mentioned above we found similar rate of decomposition for horticultural peat and for the organic matter in mineral soils. This figure of Kortleven might therefore be adopted as a first approximation for the breakdown of horticultural peat after liming. Thus, raising the pH of the peat by three units by liming would mean that in time about 12 per cent more of the peat will be broken down to CO_2 than without liming.

EXTENT OF PHYSICAL IMPROVEMENT

The physical improvement of the soil achieved by applying horticultural peat depends on the physical properties of the peat and on those of the soil. The physical properties of trade quality of horticultural peat show a rather wide variation depending upon the freezing conditions (van Dijk and Boekel, 1965), degree of decomposition of the peat, shredding, etc., viz.: pore volume 86 - 91 per cent; volume weight 13 - 22 g dry matter/100 ml; volume percentage of air at pF2 28 - 48, and of water 40 - 60 (corresponding to 200 - 360 g water/100 g dry matter); volume percentage of air at pF1 2 - 20, and of water 70 - 90 (corresponding to 360 - 540 g water/100 g dry matter).

These data refer to peat compressed in the same way as is done with potting soils. Typical pF-curves of shredded, humified raised-bog peat, raw as well as air-dried, and of shredded peat previously frozen, moist as well as air-dried, together with some characteristic data, are shown in Figure 5. From these data it is evident that the volume per cent of water from pF 2.0 - 4.2 and of air at pF 2.0 are increased by freezing. Drying without previous freezing results in a heavy loss of water capacity.



1 – raw, shredded
2 – shredded and air-dried
3 – frozen and shredded
4 – frozen, shredded and air-dried

NOTE:

	1	2	3	4
volume per cent water at pF 2.0 – 4.2:	34	6	43	36
volume per cent air at pF 2.0:	26	62	30	38

Figure 5. pF-curves of highly humified raised-bog peat.

As these physical properties of horticultural peat are much better than those of most mineral soils, the latter can be ameliorated considerably by mixing with this peat (Table V). In clay soils, the pore space increases on the average 1.8 volume per cent, the water volume 0.5 per cent and the air content 1.3 volume per cent for every increase of 1 per cent in the organic-matter content.

In sandy soils, moisture and air volume increase to about the same extent.

It was found that the volume ratio, solids : water : air, found in the first years after application of the peat, nearly corresponds with the ratio as calculated from both separate components. This indicates that the properties of the original soil particles do not change, but that the spatial construction of the soil has improved, that of the added peat being better. After some years, however, the favourable effect of mixing soil with peat somewhat recedes, presumably because of some disintegration and degradation of the peat material.

On heavy clay soils the application of horticultural peat also facilitates tillage. In this respect, an organic-matter content of 8 - 9 per cent should be the minimum. To achieve this for a soil with 3 - 4 per cent organic matter, a layer of 8 - 10 cm depth of peat is necessary.

For potting soils, intended for use in floriculture it is required that the volume ratio, solids : water : air at pF 1.5 should be at least $< 40 : > 40 : > 20$. To achieve that, mixing with more peat may be required, even up to the ratio of 1:1, as is shown in Table VI. Culture tests indicated that the optimal mixing ratio of clay and peat is even higher, viz., 1:5. It is worthy to note that the gain in volume per cent of water at pF 1.5 by mixing with peat practically represents the gain in volume per cent of available water for the plants (pF 1.5 - 4.2; last column of Table VI).

TABLE V

Influence of Horticultural Peat on the Volume Ratio, Solids : Water : Air, of Different Mineral Soils at pF 2

	Original soil				After mixing with peat			
	Per cent org. matter	vol. per cent			Per cent org. matter	vol. per cent		
		solids	water	air		solids	water	air
clay soils								
I	6.4	35.9	39.8	24.3	10.0	29.9	40.2	29.9
II	4.2	41.7	42.0	16.3	5.8	39.0	44.2	16.8
III	3.6	43.0	40.3	16.7	5.7	38.5	41.5	20.0
IV	2.6	43.8	31.1	25.1	4.1	41.0	31.9	27.1
V	2.7	43.7	34.3	22.0	4.3	40.5	35.4	24.1
sandy soils								
I	2.0	45.4	36.4	18.2	4.1	40.5	38.2	21.3
II	1.3	49.4	29.8	20.8	3.5	45.8	32.2	22.0
III	5.5	46.4	23.2	30.4	7.2	40.8	25.8	33.4

TABLE VI

Influence of Mixing Ratio of Heavy Clay with Horticultural Peat on some Physical Properties

vol. ratio	vol. per cent at pF 1.5			vol. per cent water
clay : peat	solids	water	air	pF 1.5 – 4.2
6 : 0	35	36	29	19
5 : 1	32	40	28	23
4 : 2	29	41	30	24
3 : 3	26	46	28	30
2 : 4	21	49	30	34
1 : 5	16	52	32	34
0 : 6	10	53	37	37

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