Nitrogen Investigations in Peat Based Artificial Soils under Plastic House

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Introduction

Peats are generally used for ornamental plants as well as vegetable cultivation under glass- and plastic houses. These mining products have special advantages as growing media, as they are weed and parasite free and almost sterile. Several physical and chemical properties make peats a very suitable medium for plant growth.

The peatlands of the World represent the first stage of fossil biomass accumulation. They contain two important components of the biogeochemical cycle, carbon and – an important structural element of the cell – nitrogen. Hungary, with small, but not neglectable peat areas, ranks among the first 20 countries in the World with regard to peat area. Hungary is relatively abbundantly supplied with peat, about 10.7% of the country's territory is covered by peat. The percentage of total world resources is 0.04 (ROBINSON &.LAMB, 1975; GÖTTLICH, 1982).

Experiments were carried out for several years to investigate the applicability of peat based soil mixtures in horticulture, above all in vegetable cultivation under plastic house.

The aim of this study was to characterize some low moor peat materials and to compare them with man-made horticultural soils. Another goal was to investigate the effect of liming on the N content of peat based soil mixtures and on the yield of tomato plants.

Materials and Methods

Very dissimilar kinds of peat can develop due to the differences in species composition in the natural vegetation of peatlands. Most of the peatlands in Hungary originate from lakes, they belong to low moor peats. Their properties

differ from those of high moor peats, which develop under the effect of climate and are fed by rainfall.

Their properties are unlike those of sphagnum peats, as regards utilization. The structure is less fibrous, they are more humificated and may also contain lime. The forming of low moors is determined by the configuration of the terrain, they do not depend on climate. Reed, bulrush and sedge provide raw material for peat formation, which obtained nutrients from the mineral subsoil. Hence, peat originating from these plants has a high mineral content. It has been known since the beginning of the century (VAJDA, 1912) that Hungarian low moor peats have higher N content in opposition to high moor peats.

The determination of different N forms was carried out by the combined oxidative hydrolysis method (HARGITAI, 1960). 10 g of air-dried peat is treated with 100 cm^3 of 0.25 *M* H_2SO_4 in an Erlenmeyer flask. After shaking by hand for 1-2 minutes the samples are left to hydrolyze overnight at room temperature. The hydrolysates are filtered on analytical filter paper on the following day, and the solutions are analyzed for their N content. The peat is kept on the paper 24-30 hours to air-dry. The peat sample is then repeatedly treated with 0.25 *M* H_2SO_4 in the same way as three times before. The fifth step is an oxidation carried out with 3% H_2O_2 in 0.25 M H_2SO_4. The released N is determined in the same way as in the hydrolysates. In the sixth and last step, the same peat sample is then treated as in the first four steps.

Typical problems of cultivation in plastic house are high temperature and humidity during summer, as they induce peculiar nutrient dynamics of plants. The transpiration flow is inhibited, so the apoplasmatically moving ions, such as Ca, can be transported more slowly from the root to the shoot and later to the crop. Based on this, the effect of liming on the growth and yield of tomato varieties Tini F1 and Balca F1 was investigated in a three-year model experiment, using containers, where 17.5 g lime (T1, B1) or 35 g lime (T2, B2) was added to 7 kg Vegasca, a peat based soil mixture for vegetable cultivation.

Results and Discussion

The low moor peats of Hungary have an extremely high nitrogen content. This characteristic is very important in their application as a component in growth media prepared for intensive production. However, a low moor peatland of Western Hungary combines the advantages of high and low moors, as well (Table 1). Peats from this area have fibrous structure, low pH, high N content and continuous nutrient supplying capacity (Table 2).

Nowadays the aspects of nutrient supply, environment protection and nature conservation are also the reasons for the use of peat based soil mixtures in horticulture instead of pure peat cultures. The first peat based artificial soil was made in Great Britain, which – in addition to peat mineral matters – contained sand and loam. Similarly, in the utilization of peatlands in Western Hungary

Table 1

Agrochemical parameters of some low moor peats of Western Hungary

Site	Peat material	pH (H_2O)	$CaCO_3$ %	Organic matter, %	Salt content, %	Total N mg/100g	Available		
							N	P_2O_5	K_2O
							mg/100 g		
Királyté	fibrous	3.76	-	75.4	1.8	1523.3	77.1	6.0	7.8
Királyté	fibrous, ground	4.17	0.3	56.7	2.2	1783.9	139.0	16.0	7.4
Királyté	mixed, ground	5.16	-	42.5	1.7	1238.5	82.3	9.5	12.5
Hosszúdomb	fibrous	4.35	-	64.7	1.3	1429.1	87.1	7.0	15.0
Hosszúdomb	fibrous, ground	4.25	-	49.8	2.3	1543.0	162.9	19.0	10.5

Table 2

Nitrogen forms and N supplying capacity of some low moor peats from Western Hungary (N mg/100g)

Site	Peat material	NH_4-N	NO_3-N	Steps of combined oxidative hydrolysis						
				I.	II.	III.	IV.	V.	VI.	I-VI.
Királyté	fibrous	25.8	26.1	77.1	31.7	30.7	26.1	78.6	15.7	165.6
Királyté	fibrous, ground	3.9	90.0	139.0	30.0	25.3	19.2	310.0	76.2	213.5
Királyté	mixed, ground	5.8	38.0	82.3	24.4	20.2	18.3	205.6	74.9	145.2
Hosszúdomb	fibrous	11.5	66.0	87.1	33.4	28.7	24.8	100.1	71.8	174.0
Hosszúdomb	fibrous, ground	13.8	78.3	162.9	31.3	21.8	20.4	139.6	102.1	236.4

Table 3

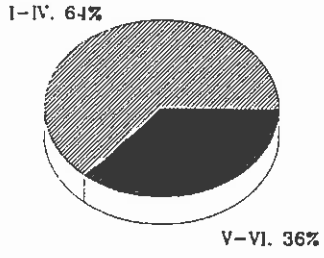
Agrochemical parameters of peat based artificial soils for horticultural utilization

Name	Utilization	pH (H_2O)	$CaCO_3$ %	Organic matter, %	Salt content, %	Total N mg/100g	Available		
							N	P_2O_5	K_2O
							mg/100 g		
Vegasca	vegetable cultivation	6.85	2.28	33	1.3	1791.4	68.5	145.0	337.0
Florasca A	ornamental plant cultivation, acidic	5.85	0.9	29.6	1.6	815.8	75.7	68.0	56.0
Florasca B	ornamental plant cultivation, neutral	6.85	0.6	26.2	1.0	747.9	36.8	95.0	190.0
Florasca C	ornamental plant cultivation, alkaline	7.02	6.0	26.3	1.5	1045.8	29.0	102.5	265.0

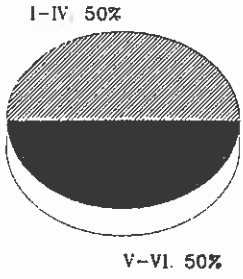
Table 4

Nitrogen forms and N supplying capacity of peat based artificial soils for horticultural utilization (N mg/100g)

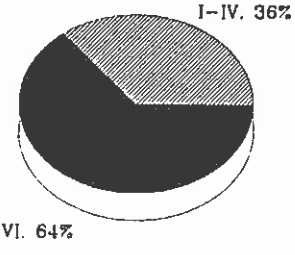
Name	Utilization	NH_4-N	NO_3-N	Steps of combined oxidative hydrolysis						
				I.	II.	III.	IV.	V.	VI.	I-VI.
Vegasca	vegetable cultivation	3.0	12.0	68.5	11.2	8.1	7.8	151.4	32.5	95.6
Florasca A	ornamental plant cultivation, acidic	3.6	51.7	75.7	18.3	16.3	13.2	177.7	43.6	123.5
Florasca B	ornamental plant cultivation, neutral	3.7	19.4	36.8	16.7	15.5	14.8	165.5	43.3	83.8
Florasca C	ornamental plant cultivation, alkaline	3.3	9.1	29.0	15.4	15.1	15.0	175.2	41.7	74.5



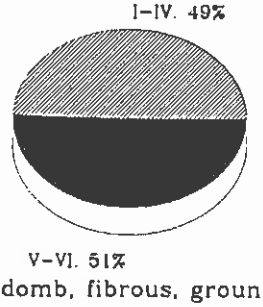
Királytó, fibrous peat



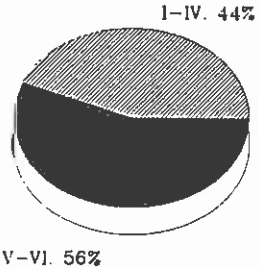
Hosszúdomb, fibrous peat



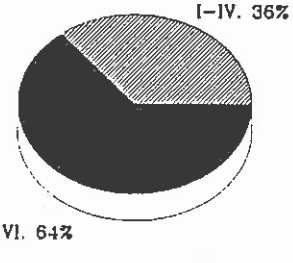
Királytó, fibrous ground peat



Hosszúdomb, fibrous, ground peat



Vegasca soil mixture



Florasca A soil mixture

Figure 1
Nitrogen forms in the studied peats and artificial soils

low moor peats are mixed with inorganic components. In order to enhance biological activity compost is added, too. Their important agrochemical properties are: organic matter content, available nutritive matter content, lime content, pH value, nutrient supplying capacity (Table 3).

In this way a soil mixture of continuous nutrient supplying capacity, similar to natural soils, is obtained. There are different man-made soils for vegetable and ornamental plant growth (Tables 3 and 4). The most important fraction of N, from practical point of view, is the total easily hydrolyzable N, because these nitrogen forms – the first four steps combined – express the total easily available nitrogen. The oxidation products in the fifth and sixth steps characterize the more strongly bound potentially available N forms. The soil mixtures (Vegasca, Florasca) contain this N form in higher proportion (60%) than fibrous peats. It represents reserve nutrients for the plants and provides continuous, steady nutrient supply during the whole vegetation period (Figure 1).

One of the most relevant practical problems of cultivation under glass- and plastic house is the interaction between soil and plant. The nutrient uptake by the plant and its translocation into the different parts of the plant are of particular importance. Because of the high humidity, Ca uptake is slow under plastic house. The Ca effects root formation and thus, the nutrient supply of the whole plant is limited. The lime content of the soil also plays an essential role in the mobilization of organic matters and nutrients, respectively. It can be assumed that plants, particulary the calcium demanding tomato, require higher lime content of the soil.

On the basis of the experiments it can be stated that tomato grown in medium with high organic matter content under glass and plastic house reacted positively to the higher lime concentration of the soil. Probably, tomato, depending on the variety, requires higher lime content. Balca F1 responded more sensitively to the elevated lime content, producing a higher yield with the smaller lime dose, the three-years mean being 1.45 kg/plant as compared to 1.12 kg/plant for the control, without supplying any other nutrient. Tini F1 gave a better yield (1.32 kg/plant) with the higher lime dose (Table 5). The negative effect of the higher lime dose was that the stem and young shoots became more fragile.

Table 5

Effect of liming on the yield of tomato plants (numbers represent the means of three years)

	Total yield (kg)	kg/plant		Total yield (kg)	kg/plant
T0	17.395	1.087	B0	17.902	1.119
T1	20.497	1.281	B1	23.202	1.450
T2	21.130	1.320	B2	21.471	1.342

The investigation and experiments show that low moor peats can be applied successfully in horticultural cultivation. The high nitrogen content of peat provides a potential N resource for the plant (FORRÓ, 1990), which can be modelled by combined oxidative hydrolysis. Mobilization of nitrogen can be enhanced upon the effect of environment-friendly lime. Low moor peats, possibly containing more lime, can also be utilized successfully in horticulture.

Summary

The physical and chemical properties of peats make them a very suitable medium for plant growth: they are weed and parasite free, almost sterile, and contain carbon and nitrogen, two important components of the biogeochemical cycle.

Nowadays, however, nutrient supply, environmental and nature protection aspects are also the reasons for the application of peat based soil mixtures in horticulture instead of pure peat cultures.

The structure of Hungarian peats is less fibrous, they are more humificated and may also contain lime. In the utilization of the peatlands in Western Hungary low moor peats are mixed with inorganic components. In this way a soil mixture of continuous nutrient supplying capacity, similar to natural soils, is obtained. To enhance biological activity compost is also added.

Experiments were conducted for several years to investigate the applicability of peat based soil mixtures in vegetable cultivation under plastic house, as well as the effect of the apoplasmatically transported and – because of the high humidity – slowly moving lime on the nitrogen content of peat.

It can be assumed, that the high nitrogen content of peat was mobilized upon the effect of lime and it also influenced the yield of tomato plants. The vegetables cultivated under plastic house require and tolerate the higher lime content of the soil mixtures. Therefore, low moor peats possibly containing more lime can also be utilized successfully in vegetable cultivation under plastic house.

Acknowledgement

This research was supported by the Hungarian National Scientific Research Foundation (OTKA) under grant No. 17297.

References

FORRÓ, E., 1990. Application of peat based soil mixture in intensive vegetable cultivation. In: „Peat Use and Peatland Conservation" Joint Symposium of Comm. II., IV. and VI. of the International Peat Society, Keszthely, Hungary, September 2-8.

GÖTTLICH, K. H., 1982. Moor und Torfkunde. Schweizerbartsche Verlagsbuchhandlung. Stuttgart.

HARGITAI, L., 1960. Investigations on humic substances in the main soil types. (In Hungarian) C. Sc. Thesis. Hungarian Academy of Sciences. Budapest.

ROBINSON, D. W. & LAMB, J. G. D., 1975. Peat in Horticulture. Academic Press. London.

VAJDA, Ö., 1912. Utilization of Peat Moors in Hungary. (In Hungarian) Pátria Irodalmi Vállalat és Nyomdai Rt., Budapest.