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PEAT-SUBSTITUTING MATERIALS IN GREEN PEPPER GROWING

Thesis of the PhD dissertation

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Introduction, objectives

The possible yielding and the quality of the produced vegetables are mainly determined by the characteristics of the applied media or soil mixtures and the nutrient-supplying systems of horticulture.

In Hungary the applying of peat-based soil mixtures (Florasca, Vegasca) have spread from the 1960s. As a result of their presence were avoidable the deterioration of soil quality in greenhouses. On the other hand the output of intensive industries (ornamental plant- and vegetable growing) have grown largely.

Peats have got specific physical and chemical characteristics therefore it is one of our most ideal growing media up to now. But as a result of the intensive exploitation our peat resources were decreased and the conditions of peat exploitation going to be more restricted in the future. There is a more severe problem as a result of peat exploitation the extinction of several plant and animal species is threatening continuously. These processes are possible reversible because nowadays carrying out the reconstruction working of the exploited areas are compulsory.

Peat is a reviving material although the process of its developing is rather slow. Recently some experiments were carried out with the aim of finding natural materials which may substitute for peat fully or partly. Recent ideas are aiming at utilising wastes of agriculture, food-industry, forestry and households as soil mixture components in horticultural production.

The utilization of these organic wastes provide an efficient and cost-effective method for disposal for these materials. Beside the substituting role of these organic materials, they contribute the environmental protection of peat areas and the sustaining of the ecological balance of the Earth.

In the present study the suitability of green waste composts, pine bark and peat-based media for green pepper forcing has been assessed. A vegetable forcing experiment was set up in the Bocskai István Reformed Secondary School in a 300 m^2-sized plastic house (type: Filclair) between with green pepper (*Capsicum annuum L.,* variety Danubia) test plant. Among the examined media there were peat-based mixtures and peat-free materials.

During the experiment the changes occuring in plants and soils were investigated, too. The effects of different organic-originated media on the growth and cropping of green pepper were evaluated. The pedological characteristics of each medium and the changes of these parameters during the whole growing period were investigated. The advantageous and disadvantageous properties of peat-free media were determined compared to peat-based mixtures. The stability of humic substances and the turnover of different nitrogen forms contained in growing media was also determined during the vegetation period. It was studied how the degree of humification of a medium may influence the productivity of a crop grown on it.

We found the way that peat-free media how applying efficiently in intensive production. Our main objective was to know whether the examined peat-free media are suitable for substituting for peat fully or partly in vegetable forcing.

Method and materials

A green pepper forcing experiment was set up in the experimental farm of the Bocskai István Reformed Secondary School together with the Department of Soil Science and Water Management of the Corvinus University of Budapest. A green pepper forcing experiment, using different growing media of organic origin, in a 300-m^2 plastic house (type: Filclair) was carried out between 2002 - 2004.

Eight types of organic media were tested:

1. **Vegasca:** industrial soil mixture, its raw material was the peat of Hanság
2. **Green waste compost I.**– originated from Budatétény, made of all kinds of plant remains from households and grass mowings
3. **Green waste compost II. 50%+ sand 50%:** originated from Tura, made of all kinds of plant remains from gardens and households and mixed with sand in a ratio of 50-50%, we used it just in 2002 and 2004
4. **Pine bark:** it was the bark of *Picea* with 1-40 mm pore-sized constituents, we used it after grinding and 1- year composting
5. **High-moor peat:** 100% high-moor peat (AgroCs brand) + 2 kg/m^3 PEAT-mix (slow- release fertilizer)+ 2 kg/m^3 superphosphate +3 kg/m^3 Futor (lime powder)
6. **Low-moor peat**: 100% low-moor peat (originated from Pötréte), 2 kg/m^3 PEAT-mix (slow-release fertilizer)+ 2 kg/m^3 superphosphate
7. **Peat with bentonite:** 45% high-moor peat (AgroCS brand)+ 45% low-moor peat (originated from Pötréte)+ 10% bentonite +2 kg/m^3 PEAT-mix (slow-release fertilizer)+ 2 kg/m^3 superphosphate +1,48 kg/m^3 Futor (lime powder)
8. **Low-moor-high-moor peat:** 50% high-moor peat (AgroCS brand)+ 50% low-moor peat (originated from Pötréte)+ 2 kg/m^3 PEAT-mix (slow-release fertilizer)+ 2 kg/m^3 superphosphate+ 1,5 kg/m^3 Futor (lime powder)

The composition of PEAT-mix was 13:15:17 N: P_2O_5: K_2O and the active ingredient-content of superphosphate was 18-20% P_2O_5.

The test plant was green pepper (*Capsicum annuum* L., cv. Danubia). 'Danubia' is an early bearing hybrid with indeterminate growth habit. The seeds were sown at the end of January (2002) and at the beginning of February (2003 and 2004). The seedlings were planted in 12-litre plastic containers in the Filclair plastic house, in April.

The experiment was set up in a randomised block design, in 4 replications. A single replication consisted of 5 containers of plants with one plant per container. The size of one replication was 1,2 m^2. The growing media were renewed every year.

Planting density was 4 plants per m^2. During the vegetation period all plants got an additional top dressing in a liquid form daily. Universol (3:1:5 N:P:K) fertiliser was used in 0.5 ‰ concentration and from July calcium-nitrate ($CaO:NO_3$ = 28:15.5) was added into the nutrient solution. An automatic nutrient solution-feeding system was used with trickle irrigation.

During the experiment the changes occuring in plants and soils were investigated, too.

Pedological analysis:

Samples of growing media were taken every month from the full depth (0-25 cm) of containers from June to September and analysed them in the laboratory. During the preparation of soil samples, the soils were drying out, gravels, root remains and other rubbish were removed after the soils were grinding and sieveing. The pedological analysis were made in three replications in case of each sample. Soil samples were also taken from each media before planting in April.

We determined the following pedological parameters:

1. total nitrogen content (according to the Kjeldahl-method)
2. hydolisable nitrogen content (according to the Hargitai-method)
3. NH_4-N - and NO_3-N content (according to the Bremner-method)
4. AL-P_2O_5 és AL-K_2O content
5. organic matter content (% of C)
6. stability of humus materials (Q) (according to the optical method of Hargitai)
7. calcium content (with the calcimeter of Scheibler)
8. pH from 1:2,5 and 1:5 soil:solvent extraction (with distilled water and potassium-cloride solvents)
9. electical conductivity (EC) from the extractions of 1:2 and 1:5 soil and distilled water
10. K_A value (according to the Arany-method)

The analyses were carried out according to the Pedological and Agrochemical Analytical Handbook of BUZÁS (1998). The peat-based media were analysed accoring to the MSZ-08 0012/3-79 numbered standard.

Morphological examinations:

We measured the weight and volume of every crop, we gave the number of pieces and sorted them. The yields of green pepper on each medium were also recorded.

For statistical evaluation of the data an one-way analysis of variance was applied using Microsoft Excel 2003 software. For evaluation of significance of differences (SD95%) between treatment means the t-test was used. The data of the pedological properties were averaged, at the yields and the percentage of tip rotted results the results of each year was given.

Results

All of the examined media had high organic matter content, but there were significant differences between the value of OM-Q (OM-Q expresses the quality of humic substances). Among peat-based mixtures stable humic substances dominated in Vegasca (OM-Q= 1.2) and in low-moor peat (OM-Q= 1.1). Against it raw humic substances were typical of high-moor peat (OM-Q= 0.8) (Table 1.). The mixture of high-moor peat and low-moor peat gave the highest yields because this mixture united itself the advantageous charactersitics of the two types of peats. This mixture possessed higher nitrogen content, excellent adsorption- and buffer capacity although its structure was stable and fibrous providing the appropriate water and oxygen ratio for the roots during the growing. The highest OM-Q values were found for the two types of composts (green waste compost I. OM-Q= 6.5, green waste compost II. + sand 50% OM-Q= 5.6), so the stable humic substances dominated in these media (Table 1.). In case of composts the stabilization of humic substances occur in the period of curing. The presence of the stable and good-quality humic substances improve the structure and the water- and nutrient adsorption capacity of media or soil mixtures.

Pine bark had high organic matter content (OM= 72%) but the quality of its humic substances were low (OM-Q= 0.5). Because the dominance of raw humic materials this medium had lower adsorption- and buffer capacity. As a result of it we suggest the adding of nutrient solution more intensively during the growing (Table 1.).

Table 1. Data characterizing the condition of humic substances of the examined media (2002-2004.)

Soil mixture/media	Organic matter content (OM%)	Humus stability (OM-Q)	Humus stability coefficient (OM-K)
Vegasca	**37**	**1.2**	**0.033**
Green waste compost I.	**43**	**6.5**	**0.151**
Green waste compost II. 50%+ Sand 50%	**32**	**5.6**	**0.172**
Pine bark	**72**	**0.5**	**0.007**
High-moor peat	**79**	**0.8**	**0.015**
Low-moor peat	**73**	**1.1**	**0.015**
Peat with bentonite	**54**	**0.7**	**0.013**
Low-moor-high-moor peat	**76**	**0.9**	**0.011**
SZD 95%	***3.68***	***0.61***	***0.016***

The evaluation of the electrical conductivity data of a medium shows relation with the organic matter content of it. If a medium has high organic matter content, its electrical conductivity can be high during the vegetation period while the cultivated plant will not damaged or undeveloped. Because the humic materials can neutralise the damaging salt effects. The highest electical conductivity (EC) was observed for green waste compost I. (EC= 3.5), when sand was added (in 50%) to green waste compost II. the EC of the medium decreased significantly (EC= 2.9, SD95%= 0.56) (Table 2.). The plants which were grown in the composts showed partial tolerance to the high EC because these plants were smaller and gave lower yields.
The pH of the composts (green waste compost I pHH_2O=7.3, green waste compost II. 50% and sand 50% pHH_2O=8.1) and Vegasca (pHH_2O=7.4) were slightly alkaline, differing from the optimal interval for forced green pepper (Table 2.). In these media the pH values influenced the solubility and availability of nutrients negatively therefore the yielding of these media were lower –mainly in case of composts.
The highest calcium-carbonate content were found for the two types of composts (green waste compost I. $CaCO_3$ (%) = 11.4, green waste compost II. 50% + sand 50% $CaCO_3$ (%)= 8.1. The calcium-carbonate content of peat-based media were low (about 1-2%). The lowest pHH_2O value was found for high-moor peat (pHH_2O=5.3) although this medium contained 1.8 % $CaCO_3$ (Table 2.). In case of artificial soils it can occur because Futor (calcium powder) is used for adjusting the optimal pH of

acidic peats. In the present experiment high-moor peat was completed with 3 kg/m^3, low-moor-high-moor peat with 1.5 kg/m^3 and peat with bentonite with 1.48 kg/m^3 Futor before planting.

The K_A value is suitable for the determination of the physical kinds of soils. We found that the peat-based materials had the highest K_A values (high-moor peat K_A=480) (Table 2.) it was in relation with the high organic matter content of these media. It also means that these artificial media can absorb larger amounts of water comparing to natural soils.

Table 2. The basic pedological parameters of the examined media (2002-2004.)

Soil mixture/media	pH_{H_2O}	pH_{KCl}	$CaCO_3$ (%)	K_A	OM (%)	EC (mS/cm)
Vegasca	**7.4**	**6.8**	**1.5**	**100**	**37**	**2.1**
Green waste compost I.	**7.3**	**7.1**	**11.4**	**88**	**43**	**3.5**
Green waste compost II. 50%+ Sand 50%	**8.1**	**7.6**	**8.1**	**48**	**32**	**2.9**
Pine bark	**6.6**	**6.4**	**-**	**164**	**72**	**0.6**
High-moor peat	**5.3**	**5.2**	**1.8**	**480**	**79**	**1.2**
Low-moor peat	**6.8**	**6.5**	**2.1**	**136**	**73**	**2.1**
Peat with bentonite	**6.4**	**6.0**	**1.1**	**260**	**54**	**1.2**
Low-moor-high-moor peat	**6.5**	**6.1**	**1.4**	**280**	**76**	**1.7**
SZD95%	***0.15***	***0.15***	**-**	**-**	***3.68***	***0.56***

Relation was between the humification and the distribution of the different nitrogen forms in media. When the medium is more humificated, its easily available nitrogen content decreased in relation to the total nitrogen content. Before planting in low-moor peat the hydrolizable nitrogen content in relation to the total nitrogen content was 7.7%, while the same proportion was 20.8% in high-moor peat. The other more humificated media had also low proportion of hydrolizable nitrogen (Vegasca 6.4%, green waste compost I. 5.5%, green waste compost II. 50% and sand 50% 9.8%). Because during the processes of humification the larger part of the nitrogen incorporating into the stable structure humic substances.

Before planting the peat-based media had the highest hydrolizable nitrogen content because these mixtures were added fertilizers previously. The hydrolizable nitrogen content of Vegasca, composts and pine bark were lower with 75-80%. During the growing period the nitrogen content of the media which were added fertilizers reduced rapidly, although the nitrogen content of Vegasca and pine bark reduced just slightly. In case of composts the hydrolizable nitrogen content increased slightly. These were the consequence of the intensive mineralization processes which occured in organic media. Mineralization were influenced by media and climatic conditions. According to our results mineralization were the most intensive in media with good-quality humic substances (composts). The hydrolizable nitrogen content of high-moor peat decreased from 252 mg/soil to 68 mg/soil from April to September while in green waste compost I. the hydrolizable nitrogen content decreased from 71 mg/soil to 48 mg/soil in the same decade. The adding of nutrient solution continuously also improved the intensity of mineralization processes (Table 3.).

Table 3. The changing of the hydrolizable nitrogen content of the examined media during the vegetation period (2002-2003.)

Soil mixture/media	**Hydrolizable N content (mg/100g soil)**					
	Before planting	June	July	August	September	**SZD 95%**
Vegasca	**74**	**33**	**55**	**31**	**29**	***10.93***
Green waste compost I.	**71**	**99**	**100**	**63**	**48**	***25.61***
Green waste compost II. 50%+ Sand 50%	**52**	**-**	**89**	**74**	**59**	***20.48***
Pine bark	**41**	**32**	**39**	**34**	**34**	***9.92***
High-moor peat	**252**	**163**	**161**	**76**	**68**	***26.29***
Low-moor peat	**132**	**146**	**148**	**93**	**71**	***24.21***
Peat with bentonite	**151**	**115**	**120**	**82**	**63**	***18.72***
Low-moor-high-moor peat	**209**	**144**	**158**	**78**	**61**	***21.81***
SZD 95%	***23.82***	***21.69***	***26.13***	***12.52***	***10.55***	

We found that the potassium content of composts (green waste compost I. AL-K_2O= 460 mg/100g soil, green waste compost II. 50% + sand 50% AL-K_2O= 386 mg/100g soil) approached the potassium content of peat-based media (high-moor peat AL-K_2O= 504 mg/100g soil, low-moor peat AL-K_2O= 484 mg/100g soil, peat with bentonite AL-K_2O= 372 mg/100g soil, low-moor-high-moor peat AL-K_2O= 497 mg/100g soil) although composts were not added fertilizers. Pine bark (AL-K_2O= 305 mg/100g soil) also had remarkable potassium content. During the growing period composts and pine bark preserved a considerable part of their available potassium content (Table 4.). According to us these materials can have great importance as slow effect potassium sources in soil mixtures.

Table 4. The changing of the AL-K_2O content of the examined media during the vegetation period (2002-2003.)

Soil mixture/media	AL-K_2O content (mg/100g soil)					
	Before planting	June	July	August	September	**SZD 95%**
Vegasca	**204**	**151**	**175**	**126**	**109**	***33.1***
Green waste compost I.	**460**	**551**	**619**	**640**	**565**	***187.6***
Green waste compost II. 50%+ Sand 50%	**386**	**-**	**584**	**286**	**178**	***98.1***
Pine bark	**305**	**292**	**261**	**230**	**207**	***46.1***
High-moor peat	**504**	**251**	**266**	**219**	**147**	***50.6***
Low-moor peat	**484**	**222**	**248**	**191**	**138**	***53.9***
Peat with bentonite	**372**	**169**	**196**	**152**	**135**	***34.6***
Low-moor-high-moor peat	**497**	**257**	**282**	**185**	**157**	***50.6***
SZD 95%	***42.6***	***72.3***	***71.9***	***98.5***	***107.3***	

If the available potassium content of the media are extremely high, the availability of the calcium is limited because potassium and calcium are antagonists. In case of green pepper the deficiency of calcium causes tiprotting. It is a severe problem because it deteriorates the saleability of the fruits. We picked the most tiprotted fruits from those plants which were grown in composts and high-moor peat. The pH-value of high-moor peat was low and the solubility of the calcium is also limited when the pH value of soils are low (acid) (Figure 1.).

The mixture of high-moor and low-moor peat (9.3 kg/m^2) and peat with bentonite (8.9 kg/m^2) gave the highest yields.The composts (green waste compost I. 6.1 kg/m^2, green waste compost II. 50% + sand 50% 5.7 kg/m^2) gave the lowest yields (Figure 2.).

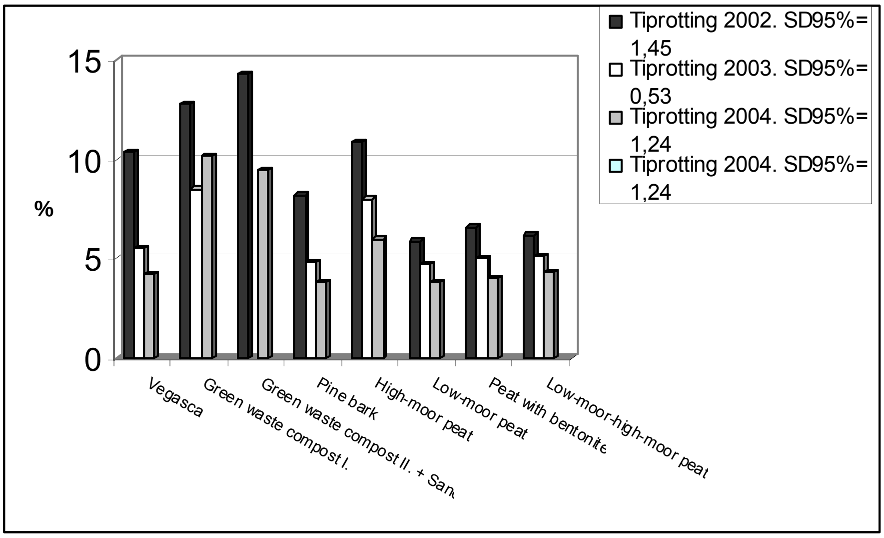

Figure 1. The proportion of the tip rotted fruits at each media (2002-2004.)

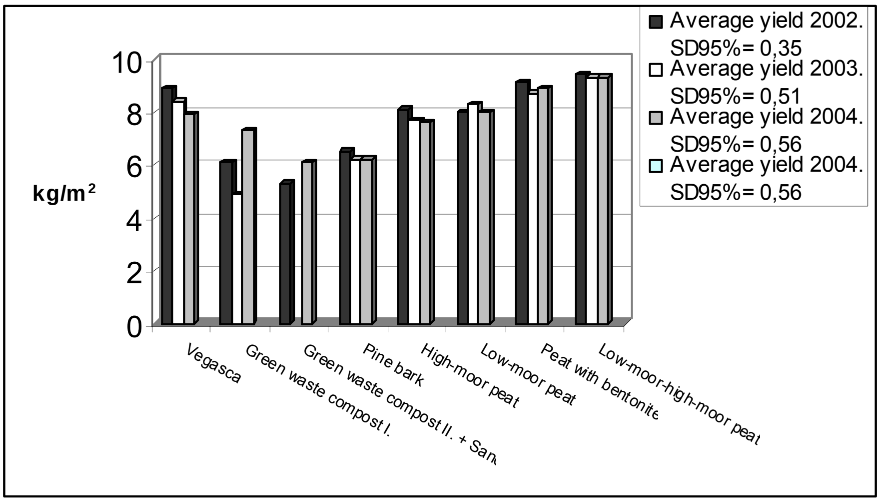

Figure 2. The changing of the yields at each media (2002-2004.)

We found that the multi-componential, peat-based media gave the highest yields. The examined pine bark does not substitute for peat fully. We suggest using pine bark after grinding and composting because these treatments improve the wettability and the adsorption- and buffer capacity of this medium. The examined composts were properly manufactured and sterile, but cause of their alkaline pH and high potassium content were not ideal for green pepper. The potassium- and phosphorus content of pine bark and composts were also remarkable, as a result of it these materials can have great importance as slow effect nutrient sources in soil mixtures.

New scientific results

Our main object was to know whether the examined peat-free media are suitable for substituting for peat fully or partly in vegetable forcing.

1. We found that the multi-componential, peat-based media gave the highest yields. So the fully substitution of peats was not possible with the examined peat-free materials.

2. The highest OM-Q and OM-K values were found for the two types of composts. The presence of the stable and good-quality humic substances improves the structure and the water- and nutrient adsorption capacity of these media which improves the growing safety in case of composts.

3. The presence of stable and good quality humus materials is typical of low-moor peat and the presence of raw and less humificated humus materials is typical of high-moor peat.

4. When the medium is more humificated, its easily available nitrogen content decreased in relation to the total nitrogen content. During the processes of humification the larger part of the nitrogen incorporating into the stable structure humic substances.

5. Before planting the peat-based media had the highest hydrolizable nitrogen content because these mixtures were added fertilizers previously. The hydrolizable nitrogen content of Vegasca, composts and pine bark were significantly lower. During the growing period the nitrogen content of the media which were added fertilizers reduced rapidly, although the nitrogen content of Vegasca and pine bark reduced just slightly. In case of composts the hydrolizable nitrogen content increased slightly. Among peat-based media the most intensive mineralization occured in low-moor peat.

6. As an effect of the extremly high potassium content of composts the proportion of the tiprotting fruits increased significantly.

Results utilizable for practice work

1. It is advantageous to use mineral and organic components - or to use organic components with different C/N proportion - together in soil mixtures. These mixtures provide balanced and continuous nutrient supply and have appropriate adsorption- and buffer capacity. The presence of the mineral components ensure the stable structure in mixtures.

2. There were significant differences between the yielding of peat-based and peat-free media. The low yielding of composts were in relation to their high electrical conductivity and their alkaline pH.

3. We suggest using pine bark after grinding and composting because these treatments improves the wettability and the adsorption- and buffer capacity of this medium.

Conclusions, suggestions

1. Pine bark requires adding top dressing more frequently because of it more complicated wettability.

2. The applying and spreading of pine bark is limited in Hungary mainly for economical reasons. At present the peat is available cheaper (3000 – 4000 Ft/m^3) than the pine bark (7000 – 8000 Ft/m^3).

3. Composts are suitable only for the partly substitution for peats. Usually composts do not have a standard quality, because of it their applying will result changing yields and quality. In the horticultural growing composts can be use after curing, because the phytotoxic compounds can decay just in mature composts.

4. The pH of composts are differeing from the optimal interval for the most ornamental plant- and vegetable species. The solubility and the availability of nutrients are optimal just in that pH interval which is appropriate for the cultivated plant.

5. We suggest to use composts with mixing some mineral component. But we have to control the pH of the mineral component because if the inorganic material has high pH, it will increase the pH of the compost-based soil mixture, too.

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2. Kappel N., Tóth K., Irinyi B., **Sári Sz**. (2003): Foszforellátás és talajszerkezet hatása a paprika tálcás palántanevelésében. MTA Növénytermesztési Bizottság III. Növénytermesztési Tudományos Nap (Proceedings) Budapest 391-395.

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