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Composted and natural organic materials as potential peat-substituting media in green pepper growing

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Summary: Peat is the most favourable and usable medium in vegetable and ornamental plant forcing but because of the intensive exploitation peat resources decreased significantly all around the world. As peat-reserves run out the use of pine bark, composts and other organic materials spread in horticultural growing. In this study we compared the suitability of peat-based media to pine bark and two types of composts. We examined the effect of different organic materials on the growth and yield of green pepper (*Capsicum annuum L., variety Danubia*). We found that the most developed plants were grown in peat-based media and pine bark. The average fruit weight was the highest in low moor-high moor peat mixture and pine bark. The plants which were grown in composts fell short of our expectations.

Key words: peat-free, compost, pine bark, nitrogen, humus, green pepper

Introduction

In this study we examined different organic materials as possible growth media for green pepper (*Capsicum annuum L., variety Danubia*). We compared the use of well-tried peat-based media to pine bark and two types of composts with the aim of finding natural materials which may substitute for peat fully or partly. This is a hot problem since peat is the most favourable medium but because of the intensive exploitation peat resources decreased considerably all around the world.

We examined organic materials, these materials contain different nutrients and possess interesting dynamics of these nutrients. Organic media contain a very important group of organic matters called humus compounds. Humic substances are responsible for the appropriate structure and the availability of nutrients and these compounds give the adsorption- and buffer-capacity of media. Stable structure is the basis of constant and appropriate porosity which establishes the appropriate water-oxygen ratio for plants and microorganisms. The aeration of soils regulates the adsorption and solubility of nutrients (*Terbe*, 1997). During the vegetation period organic matters begin to decompose and as a result of it nutrients become available (*Kappel* et al., 2003). While in natural soils usually the processes of humification are dominant, in cultivated area and in artifical media the processes of mineralization are enhanced (*Forró*, 1999). Mineralization is continuous during the vegetation period although it is affected by environmental and microbiological factors and the quality of raw materials (*Sims*, 1995). High temperature and irrigation provide favourable conditions for rapid mineralization of nitrogen from organic media. To estimate the amount of mineralised nutrient from organic media we have to know some factors for example the nutrient concentrations and the C/N ratio of media (*Hadas Portnoy*, 1997). According to *Hargitai* (1989) if the C/N ratio is low, the stability of humic substances is better and consequently the amount of hydrolizable (mobile) nitrogen increases.

In organic media humic substances absorb the nutrient surpluses and neutralize the ions of toxic heavy metals. By using these media technological mistakes can be eliminated easier. Inorganic substrates have ideal physical properties, they are sterile but do not contain nutrients and their adsorption-capacity is low. It means that the use of inorganic media require more expertise and provision from growers.

In Hungary the most popular organic-originated medium is peat. High moor peats have more advantageous properties because their structure is stable, fibrous and elastic, their salt content and reaction are low (*Terbe*, 1997). The structure of low moor peats is less fibrous and as an effect of frequent irrigations it becomes compacted, therefore growers use it in soil mixtures. The reaction of low moor peats are neutral, they are more humificated and contain more nutrients (*Forró*, 1997).

As peat reserves run out the use of pine bark, composts and other organic materials spread in horticultural growing (*Flegmann Raymond*, 1977, *Khaled Nagy*, 1993). Composts have appreciable quantities of nutrients, possess high potassium-content and relatively high soluble nitrogen-content (*Hargitai*, 1970), their reaction is usually alkaline. Its structure is less porous (*Roe* et al. 1997) and immature composts can contain phytotoxic compounds (*Chen Inbar*, 1993), these factors affect emergence and seedling growth unfavourably. Pine bark has some advantageous properties its structure is stable and loose, its reaction is slightly acid. Pine bark has wide C/N ratio, this is why during its decomposition relative nutrient-deficiency may occur (*Sramek Dubsky*, 1997). Recent ideas are aiming at utilising wastes of agriculture, food industry and forestry as soil mixture components (*Fischer*, 1986, *Remmers*, 1989). The utilization of these organic wastes provides an efficient and cost-effective method of disposal for these products (*He* et al. 2000).

Material and method

We set up our experiment in a 300 m^2-size plastic house Type: Filclair of the Halásztelek Reformed Vocational School in 2002, 2003 and 2004.

The test plant was green pepper *Capsicum annuum L.*, variety Danubia. Danubia is an early maturing hybrid with indeterminate growth habit. Its foliage is medium-green coloured, its crop is cone-shaped and white-coloured with sweet taste. It is resistant to TMV. During its growing we have to provide continuous nutrient-supply.

Seeds were sown in rockwool trays in January, then we planted the transplants with 5–6 leaves in pots in March. Plants were transplanted in April to the plastic house, there we planted green peppers in 12 litre plastic containers. 8-types of growing media were designed: 1. Vegasca, industrial soil mixture for vegetables (we used it as control) 2. communal compost, mixed-compositioned made from plant remains, domestic and industrial waste, 3. plant-originated compost made from just plant remains and mixed with sand in a ratio of 50–50, 4. pine bark – with 1–20 mm pore-sized constituents, 5. low moor peat, 6. high moor peat, 7. low moor peat mixed with high moor peat in a ratio of 50–50, 8. low moor peat mixed with high moor peat and bentonite in a ratio of 45–45–10. The peat-based mixtures were completed with starter fertilizers (2 kg/m^3 Peat-mix, 2 kg/m^3 Superfosfat) and Futor ($CaCO_3$). It was essential because peats just hardly contain nutrients in available form which is required for the plants in the beginning period of forcing (*Terbe*, 1997). We set up 4 replications with every medium.

During the experiment we examined the plants and their soils, too. We took soil samples every month from the full depth of containers and analysed them in the laboratory. We determined the pH (in H_2O), the organic matter content (%), the quality of humus materials (Q) according to the method of Hargitai, the NO_3-N content, the AL-K_2O and AL-P_2O_5 content in soil samples. The value of Q expresses the stability of humus materials, if Q1 it means that stable humus materials are in a higher ratio in the soil. With the using of humus quality and organic matter content we counted the humus stability coefficient (K), K= Q/H. We carried out the laboratory analysis of soil samples according to *Buzás* (1998).

We measured the weight and volume of every crop, we gave the number of pieces and sorted them.

During the growing we have done the following works:

Pruning: one main stem was left and led it around the supporting string as it grew during the vegetation period, other branches were cut back (*Balázs*, 1994), the shrivelled or infected leaves were removed, too.

Nutrient-supply: the plants were irrigated daily with nutrient solution. The composition changed according to the developing stages of plants N, P, K-predominanced. From July calcium-nitrate was added into the nutrient solution (*Terbe*, 2001). Green pepper has high nutrient-demand, but is very sensitive to the high salt-content of the media. Therefore it is necessary to add the nutrients continuously in smaller portions in this way the efficiency of nutrients is more perfect (*Fodor*, 1997).

Plant protection: the plants were sprayed every week or every two weeks with different fungicides (Fundazol, Amistar) and insecticides (Actara, Vertimec). We used Kasumin for prevention bacterial diseases.

Results

The optimal pH value for forced green pepper is about 6-6.5. This interval is the most efficient from the viewpont of uptake and solubility of nutrients. (*Table 1.*). The react of

Table 1 The changes of pH H_2O values in different media (2002–2003)

Growth media	pHH_2O					
	Before planting	June	July	August	September	SD 95%
Vegasca	7.4	7.6	7.1	6.9	6.9	*0.45*
Communal compost	7.3	7.3	7.2	7.1	7.1	*0.53*
Plant-originated compost	8.1	–	7.5	7.5	7.7	*0.33*
Pine bark	6.6	6.5	6.6	6.5	6.5	*0.31*
High-moor peat	5.4	5.6	5.4	5.3	5.6	*0.44*
Low-moor peat	6.8	6.5	6.6	6.6	6.6	*0.41*
Peat with bentonite	6.4	6.2	6.3	6.3	6.4	*0.28*
Low-moor-high-moor peat	6.5	6.3	6.3	6.3	6.4	*0.26*
SD 95%		*0.31*	*0.46*	*0.33*	*0.41*	*0.37*

Table 2 Organic matter content and humus quality in different media (2002–2003)

Growth media	Organic matter content (H%)	Humus quality (Q)	Humus stability coefficient (K)
Vegasca	38	1.5	0.039
Communal compost	44	7.2	0.163
Plant-originated compost	51	8.2	0.160
Pine bark	70	0.4	0.006
High-moor peat	80	0.9	0.011
Low-moor peat	75	1.3	0.017
Peat with bentonite	57	0.8	0.014
Low-moor-high-moor peat	78	1.0	0.013
SD95%	8.11	3.34	–

composts and Vegasca is lightly alkaline which can change the proportion of available nutrients. The pH values did not reduce significantly during the vegetation period because the fertilizer we used in the nutrient solution contained citric acid which prevented the acidification in media.

Pine bark had the lowest K value, it meant that this material had a wide C/N ratio (*Table 2*). Among the examined media, composts had the highest K values, indicating a low C/N ratio. During the vegetation period relatively large amount of nitrogen can mobilize from composts.

The nitrate nitrogen content was the highest in peat-based media as an effect of the added starter fertilizers. The nitrate nitrogen content of composts and pine bark was rather low but its amount increased during the vegetation period because in these organic media intense mineralization proceeded (*Table 3*).

The highest potassium-content were measured in composts (*Table 4*) as potassium represents the largest proportion in the ash of plants. Composts can be valuable soil mixture components for green pepper because of their nutrient content. From July to September the potassium content decreased significantly in every medium (except of composts) because plants took the added amount for growing. In compost the potassium-content increased as an effect of the high-adsorption capacity.

The high phosphorus-content of pine bark and composts and peats (*Table 5*) were in connection with the high phosphorus-adsorption capacity of these media. In peat-based media plants took phosphorus mainly in the beginning and middle part of the vegetation period because phosphorus is essential for rooting, blooming and yielding.

We found that the most developed plants were grown in peat-mixtures and pine bark. Plants grown in low moor-high moor peat mixtures gave the highest yield (*Figure 1*). We could pick the largest fruits from the plants which were grown in low moor-high moor peat mixtures and pine bark (*Figure 2*). Plants grown in composts fell short of our expectations in developement and in yielding, too. We found the most tiprotted fruits on those plants which were grown in composts (*Figure 3*).

Table 3 NO_3-N content in different media (2002–2003)

Growth media	NO_3-N-content (mg/100g soil)					
	Before planting	June	July	August	September	SD 95%
Vegasca	41.6	14.9	12.9	14.2	16.4	*4.48*
Communal compost	21.6	5.8	8.2	10.1	10.9	*6.79*
Plant-originated compost	32.4	–	13.9	13.9	14.1	*4.07*
Pine bark	24.3	12.2	17.1	20.4	20.1	*5.19*
High-moor peat	104.7	64.2	60.2	63.2	63.1	*7.24*
Low-moor peat	92.5	54.2	50.4	51.9	54.6	*9.94*
Peat with bentonite	76.7	36.4	34.9	43.1	42.4	*7.24*
Low-moor-high-moor peat	80.2	43.1	38.5	43.8	44.2	*7.66*
SD 95%	*4.21*	*5.35*	*6.71*	*7.26*	*8.06*	

Table 4 The potassium-content in different media (2002–2003)

Growth media	K_2O-content (mg/100g soil)					
	Before planting	June	July	August	September	SD 95%
Vegasca	204	151	175	126	109	*49.86*
Communal compost	460	551	619	883	698	*344.84*
Plant-originated compost	386	–	584	286	178	*101.66*
Pine bark	305	292	261	230	207	*71.87*
High-moor peat	504	251	266	219	147	*81.08*
Low-moor peat	484	222	248	191	138	*88.29*
Peat with bentonite	372	144	196	152	135	*64.49*
Low-moor-high-moor peat	497	257	282	185	157	*90.74*
SD 95%	*40.68*	*80.71*	*87.69*	*212.88*	*185.07*	

Table 5 The changes of phosphorus-content in different media (2002–2003)

Growth media	P_2O_5-content (mg/100g soil)					
	Before planting	June	July	August	September	SD 95%
Vegasca	190	161	138	129	149	*36.66*
Communal compost	680	583	751	630	690	*123.63*
Plant-originated compost	300	–	168	187	206	*25.03*
Pine bark	395	358	285	232	238	*40.47*
High-moor peat	520	277	266	235	300	*22.83*
Low-moor peat	525	305	295	265	322	*44.94*
Peat with bentonite	440	225	233	229	247	*39.95*
Low-moor-high-moor peat	585	293	278	290	338	*52.32*
SD 95%	*37.33*	*47.17*	*35.57*	*74.68*	*69.76*	

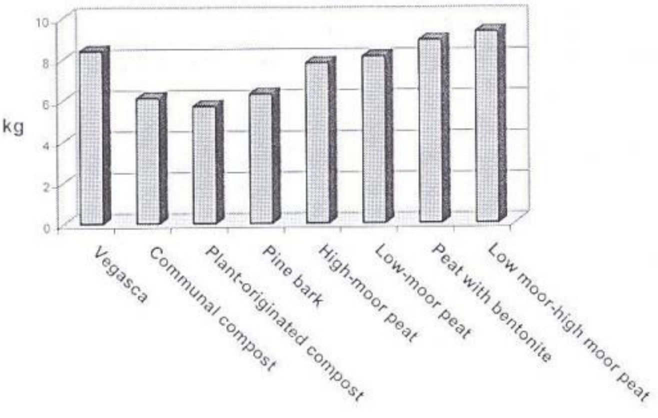

Figure 1 The average yield (kg/m²) in different media (2002–2004)

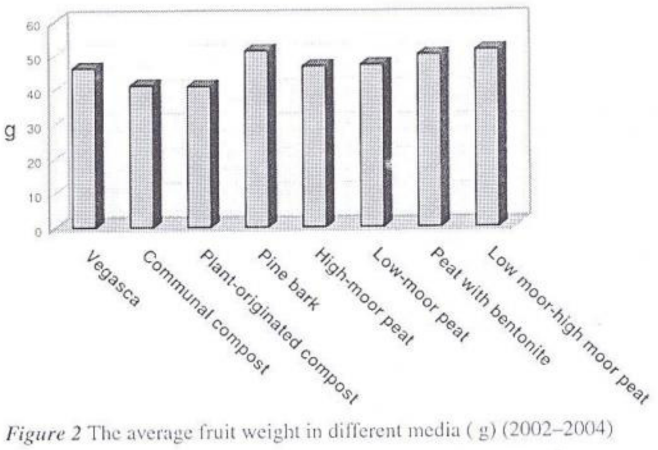

Figure 2 The average fruit weight in different media (g) (2002–2004)

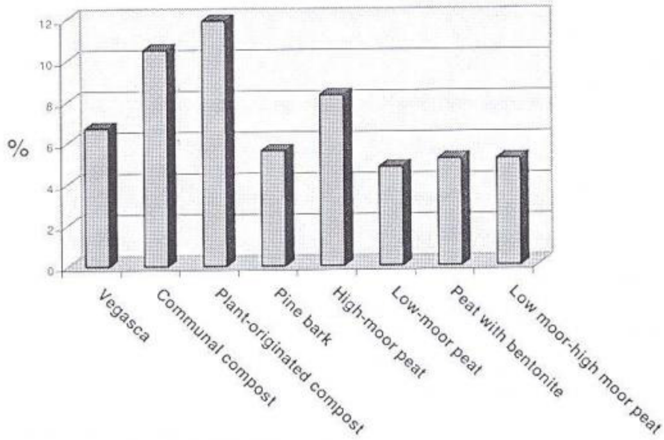

Figure 3 The changes of tiprotting in different media (2002–2004)

Discussion

The optimal pH value for forced green pepper is about 6-6.5. The pH value of composts and Vegasca were lightly alkaline which can influence the proportion of available nutrients. The pH values did not reduce significantly during the vegetation period.

Pine bark had the lowest humus stability coefficient because it had a wide C/N ratio and as a result of it during its decomposition relative nutrient-deficiency can occur. This deficiency eliminates with adding nitrogen fertilizers or top dressing during the vegetation period. Composts had the highest humus stability coefficient it meant that during the vegetation period these materials can mobilize the largest amount of nitrogen without adding any fertilizers.

The nitrate nitrogen content was the highest in peat-based media and also the highest yield was found in peat-based mixtures. The nitrate nitrogen content of composts and pine bark was rather low but its amount increased during of the vegetation period because in these organic media intense mineralization proceeded as an effect of high temperature and frequent irrigation.

The highest potassium-content were measured in composts as potassium provides the largest ratio in the ash of plants. Composts can be valuable soil mixture components for green pepper because their nutrient content. From July to September the potassium content decreased significantly in every medium except of composts because plants uptook the added amount for yielding.

The high phosphorus-content of pine bark and composts and peats were in connection with the high organic matter content of these media. In this way organic materials adsorb large amounts from phosphorus. In the beginning of the vegetation period this feathure can be disadvantageous because media do not contain enough available phosphorus and plants cannot uptake the required quantity from this nutrient. As a result of it the rooting of plants and early yielding will delay. Therefore is essential using phosphorus-dominant nutrient solution in the beginning of the vegetation period.

We found the most tiprotted fruits on those plants which were grown in composts. Tiprotting occurs when there is Ca-deficiency in soils (*Pedryc*, 1998), this deficiency is in connection with the high potassium-content of composts because K^+ and Ca^{2+} are antagonists. So if there are too much potassium in media it will prevent the availability of calcium.

According to us pine bark can be used in intensive technologies with providing continuous nutrient-supply because this medium has low nutrient storing-capacity. Those plants which were grown in composts fell short of our expectations. In our opinion composts can partly substitute for peats. Composts can be used as valuable constituents in soil mixtures, their potassium-content are high. Disadvantage that the quality of composts are fluctuating, their utility depends on the quality of raw materials and the appropriate handling.

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