Relationships between humification and productivity in peat-based and peat-free growing media

Sz. Jakusné Sári, E. Forró

Department of Soil Science and Water Management, Faculty of Horticulture, Corvinus University of Budapest, Budapest, Hungary

ABSTRACT: Peat-based and peat-free (compost) materials were tested in a vegetable forcing experiment with Danubia green pepper (*Capsicum annuum* L.). Stability and quality of humic substances and the turnover of different nitrogen forms was determined in the studied media during the vegetation period. The main objective was to find how the degree of humification might influence the productivity of a crop under greenhouse conditions. The highest humus stability and humus stability coefficient values were detected in the green waste compost. Among different peat media, the low-moor peat was more humificated than the mixture of low-moor and high-moor peat. When the medium is more humificated it has a larger mobile nitrogen reserve. However, the structure stability decreases with the increasing humification. The mixture of two types of peat had the most favourable effect on nitrogen supply and the yield of pepper was the highest when grown on this medium. The nitrogen supplying ability of the examined compost was excellent but its structure stability deteriorated during the growing season.

Keywords: compost; green pepper; humification; nitrogen; peat

It is very important to determine the degree of humification of the applied organic media, considering their suitability for intensive horticulture. Productivity of a growing medium is determined mainly by its ability of supplying nutrients and its structure stability. Both parameters depend on the degree of humification of the medium. In media of organic origin, the ability of supplying nutrients increases as the degree of humification of a medium is more advanced (Hargitai 1982). Stable structure is a basis of constant and appropriate porosity that establishes the appropriate water: oxygen ratio for plants and microorganisms. The soil aeration regulates the absorption and solubility of nutrients (Terbe 1997).

Nowadays, peat is the most favourable and popular medium of organic origin. As the peat resources decreased all over the world, numerous experiments have been carried out to find materials with similar favourable properties as peat. Green waste composts can be promising peat-substituting media in horticultural production (Remmers 1989; Sims 1995; Šrámek, Dubský 1997). Their raw materials are available in large amounts as the by-products of different industries, and they are relatively cheap.

An organic growing medium is of excellent quality if its pedological properties are similar to the properties of a good-quality natural soil. Natural soils contain organic substances responsible for their productivity. These organic substances are never constant (Stefanovits 1992; Németh 1996), one part of the organic material is mineralized and the other one is humificated. In natural soils the processes of humification are dominant, whereas in artificial soils of organic origin the processes of mineralization are enhanced (Forró 2004). Humus materials have remarkable absorption and buffer capacity; hence, they can absorb different nutrients and regulate their uptake, contributing thus to the balanced nutrient supply to the plants and protecting them from the damaging salt-effect (Stevenson 1982).

During the vegetation period organic materials accumulate in the soils in the form of plant remains; therefore the amount of the heterocyclic nitrogen slowly increases. While the amount of different amino-nitrogen forms decreases because of mineralization (Jenkinson, Ladd 1981; Mengel 1996), those amino-nitrogen forms that can be easily mineralized are bound to humic acids in the soils (Catroux, Schnitzer 1987). The available forms of mineral

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nitrogen originate from these organic amines during the processes of ammonification and nitrification (Hargitai 1961; Thicke et al. 1993).

In the present study the suitability of green waste compost and peat-based media for green pepper forcing have been assessed. The effects of different organic-originated media on the growth and cropping of green pepper were evaluated. Stability of humic substances and the turnover of different nitrogen forms contained in growing media were determined during the vegetation period. The main objective was to find how the degree of humification of a medium might influence the productivity of a crop grown on it.

MATERIAL AND METHODS

A green pepper forcing experiment, using different growing media of organic origin in a 300 m^2 plastic house (type: Filclair), was carried out in 2002, 2003.

Three types of organic media were tested:

- green waste compost – originated from Tárnok (from a Hungarian composting plant), made of all kinds of plant remains from households and grass mowing, pH 7.1;
- low-moor peat – originated from Pötréte (South-West of Hungary), black-coloured, with a fibrous structure, pH 6–7;
- low + high-moor peat – a mixture of low-moor peat with high-moor peat (AgroCs brand, light brown-coloured, fibre size 0–20 mm, pH 3–4), in the 50:50 ratio.

The peat-based media were supplemented with starter fertilizers in the following doses: 2 kg of NPK (PEAT-mix)(13:15:17) fertilizer + 2 kg of superphosphate (18–20% P_2O_5) per 1 m^3 of peat. This treatment was essential because peat contains only a small amount of nutrients in available form. Besides the fertilizers, the mixture of low-moor and high-moor peat was enriched with 2 kg Futor ($CaCO_3$) per 1 m^3 of peat. The growing media were renewed every year.

The test plant was green pepper (*Capsicum annuum* L., cv. Danubia). Danubia is an early bearing hybrid with indeterminate growth habit. The seedlings were planted in April in 12-litre plastic containers in the Filclair plastic house. Planting density was 4 plants/m^2. During the vegetation period all plants got a daily additional top dressing in a liquid form. Universol (3:1:5 N:P:K) fertilizer was used in a 0.5 ‰ concentration; from July, calcium-nitrate ($CaO:NO_3$ = 28:15.5) was added into the nutrient solution.

The experiment was set up in a completely randomized design in 4 replications. A single replication consisted of 5 containers with one plant per container.

Samples of growing media were taken every month from the full depth of containers and analyzed in the laboratory. The organic matter content (% of *C*) was determined on the basis of the organic carbon content of the soil, and the stability of humus materials (*Q*) was determined according to the method of Hargitai (1961). $Q > 1$ means that the amount of stable humus materials in the soil is higher than that of unstable compounds. From the humus stability (*Q*) and the organic matter content (*C*) the humus stability coefficient (*K*) was calculated according to the formula $K = Q/C$. The value of *K* increase as the structure of humus compounds is well developed. In the same samples, the content of the hydrolyzable-N was determined with oxidative hydrolysis according to the method of Hargitai (1961), total nitrogen by the Kjeldahl method. The hydrolyzable nitrogen content gives the amount of the easily available nitrogen forms (ammonium-, and nitrate-N and some easily available amino-nitrogen forms); for plants these are the most easily absorbable from different media during the vegetation period. The analyses were carried out according to the Pedological and Agrochemical Analytical Handbook of Buzás (1998). The yields of green pepper on each medium were recorded.

For statistical evaluation of the data a one-way analysis of variance was applied. To evaluate the significance of differences between treatment means the *T*-test was used.

RESULTS AND DISCUSSION

The organic matter content of peat-based media was significantly higher than the organic matter

Table 1. The organic matter content (*C* %), the humus stability (*Q*) and the humus stability coefficient (*K*) in the studied media; mean values of 2002 and 2003

Growing media	*C* (%)	*Q*	*K*
Green waste compost	43–44	4.4–7.1	0.099–0.161
Low-moor peat	72–78	1.1–1.3	0.015–0.016
Low-moor–high-moor peat	74–78	0.9–1.1	0.011–0.013
SD 95%	*3.76*	*0.73*	*0.017*

Table 2. The changes of the total-and hydrolyzable nitrogen content during the vegetation period; mean values of 2002 and 2003

Growing media	Before planting	June	July	August	September	SD 95%
Total nitrogen-content (mg/100 g soil)						
Green waste compost	1,210–1,354	1,006–1,246	1,238–1,316	1,108–1,176	1,878–1,954	*109.1*
Low-moor peat	1,615–1,823	1,794–1,870	1,562–1,664	1,612–1,744	1,948–2,120	*68.9*
Low-moor + high-moor peat	1,489–1,605	1,302–1,542	1,399–1,617	1,402–1,622	1,649–1,869	*96.8*
Hydrolyzable content (mg/100 g soil)						
Green waste compost	54–88	37–131	82–118	50–76	44–52	*23.8*
Low-moor peat	116–148	137–155	128–168	90–96	63–79	*25.7*
Low-moor + high-moor peat	203–215	136–152	144–172	72–84	57–65	*30.3*

content of the green waste compost. The highest humus stability (Q) and humus stability coefficient (K) values (Q = 4.4–7.1, K = 0.099–0.161) were found for compost (Table 1). According to Hargitai (1989) the high Q value indicates that the examined medium is humificated and its humus compounds have a stable structure. Among peats, the low-moor peat was more humificated than the mixture of low-moor and high-moor peat; the higher Q (0.9–1.1) and K (0.015–0.016) values were determined in this medium (Table 1). The more humificated a medium is, the higher is its mobile nitrogen reserve. However, the structure stability decreases as humification of medium advances.

Before planting, the total nitrogen content in the studied media was determined (Table 2). It was found that the examined organic media had remarkable nitrogen reserves. When the mineral fertilizers were added to the peat-based media, the proportion of the mobile nitrogen forms increased (Fig. 1). Vass (1989) found that when mineral fertilizers were added to peat, the proportion of hydrolyzable nitro-

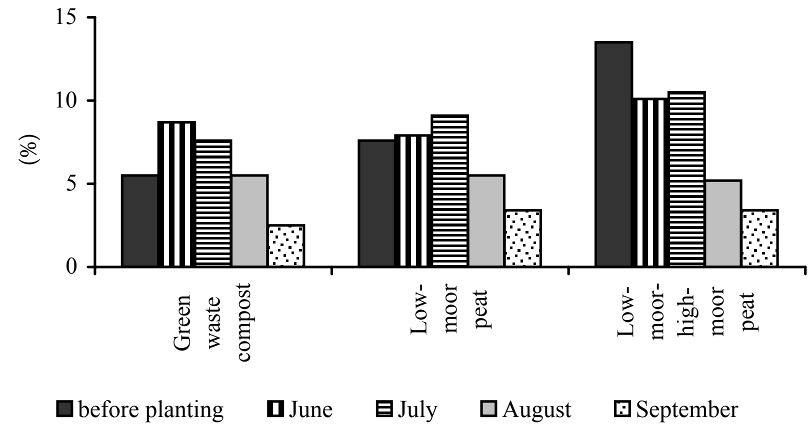

Fig. 1. Proportion of the hydrolyzable nitrogen content in relation to the total nitrogen content; mean values of 2002 and 2003

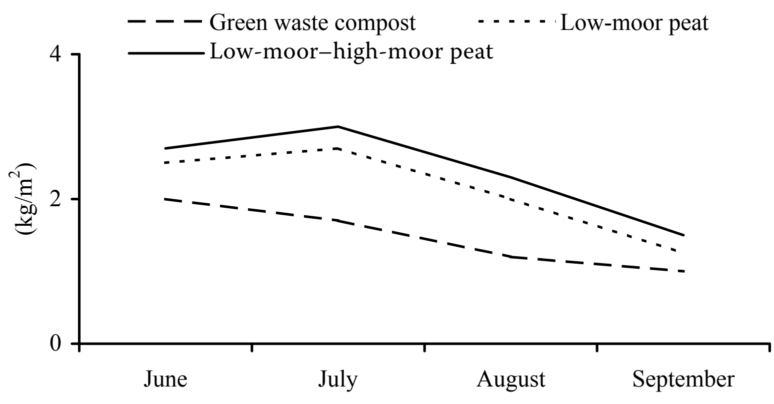

Fig. 2. Monthly yields on different media; mean values of 2002 and 2003

gen increased and the organic bound nitrogen forms were intensely mobilized. Mengel (1996) reported that during the vegetation period organic materials accumulated in soils in form of plant remains and this was apparently the reason for a successive increase of the total nitrogen content in all media in our study (Table 2).

In order to estimate the nitrogen supplying ability, the proportion of the hydrolyzable nitrogen in relation to the total nitrogen was determined. It was found that the mixture of low-moor and high-moor peat had the most favourable nitrogen-supplying ability, because the proportion of the hydrolyzable nitrogen was highest in this medium (Fig. 1). Correspondingly, the yield of green pepper was highest when grown on this medium, albeit the difference between the mixture of the two types of peat and the low-moor peat was not significant in that respect (Fig. 2). During the vegetation period, with decreasing content of hydrolyzable nitrogen content, the yields decreased. In green waste compost, significantly lower yields were recorded; this apparently resulted from its lower hydrolyzable nitrogen content and from the fact that humificated composts could not preserve their stable structure during the whole vegetation period. According to Dickinson and Carlile (1995) the decrease of the structure stability was faster in all organic peat-free media than in peats because the microbiological activity of peat-free materials was more intense. Under greenhouse conditions the frequent irrigation and high temperature provided favourable environment for microorganisms.

According to the results obtained in this study, it is more advantageous to use multi-component soil mixtures in intensive horticultural growing. A more favourable growing medium is developed when more and less humificated components are applied together; this may provide a more balanced and continuous nutrient supply and may help to preserve the structure stability. As for compost, it mixing with some mineral components (with neutral pH and low salt-content) is recommended in order to preserve the stability of its structure and to improve the release of different nutrients.

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Vztahy mezi humifikací a výnosy u pěstebních substrátů založených na rašelině a bez rašeliny

ABSTRAKT: Ve vegetačním pokusu s rychlením zelené papriky (*Capsicum annuum* L.) odrůdy Danubia byly zkoušeny pěstební substráty obsahující rašelinu a běžný kompost bez rašeliny. Během vegetačního období byla ve zkoumaných substrátech hodnocena stabilita a kvalita humusových látek a přeměna různých forem dusíku. Hlavním cílem práce bylo zjistit, jak může stupeň humifikace ovlivnit produkční potenciál této plodiny ve skleníkových podmínkách. Největší stabilita humusu a nejvyšší hodnoty koeficientu stability humusu byly zjištěny u kompostu vyrobeného ze zeleného odpadu. Z různých rašelinových substrátů byla použitá slatinní rašelina více humifikovaná než směs slatinní a vrchovištní rašeliny. S růstem humifikace substrátu se v něm zvyšoval obsah disponibilního dusíku, s pokročilejší humifikací se však snižovala jeho strukturní stabilita. Směs dvou typů rašeliny byla nejvhodnější z hlediska uvolňování dusíku a výnosy papriky byly na tomto substrátu nejvyšší. Schopnost uvolňovat dusík u zkoušeného kompostu byla výborná, avšak jeho strukturní stabilita se během vegetačního období zhoršovala.

Klíčová slova: kompost; zelená paprika; humifikace; dusík; rašelina

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Corresponding author:

Szilvia Jakusné Sári, Ph.D., Corvinus University of Budapest, Faculty of Horticulture, Department of Soil Science and Water Management, Villányi str. 29–43, Budapest H-1118, Hungary
tel.: + 36 482 6272, fax: + 36 482 6336, e-mail: szsari@mailbox.hu