Quality of Peat-Based Growing Media — What is the Current Status?©

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INTRODUCTION

German experiments have shown that the physical characteristics of peat-based growing media only play a minor role for the growth of a large range of potted plants produced in Northern Europe during normal cultivation conditions (Scharpf, 1997). During Winter and Spring 1999 no correlation was observed between the physical characteristics (water retention and particle size distribution) of peat-based growing media and the quality of the potted plants produced by several growers in Denmark. Pilot studies at the Department of Horticulture, indicated that incorporation of activated alumina (Compalox®, Alusuisse Martinswerk GmbH, Germany) in peat-based growing media, improved root growth compared to the same media without activated alumina. Incorporating small amounts of activated alumina (approximately 2 %) does not affect the physical characteristics significantly, hence improved root growth cannot be due to changed physical characteristics of the growing media, such as water retention and pore volume. This indicates that many of the problems observed in peat-based growing media are not directly/exclusively related to readily measureable parameters as texture, pH, nutrient composition, etc. However, Compalox® is capable of absorbing polar compounds and the causes could therefore also be due to toxic compounds produced by microorganisms and fungi during storage. Compounds such as phenolics are produced during decomposition of the growing media and can be toxic to plants according to Sissel Ranneklev (NLH, Ås, Norway).

Swedish results indicate, that the growth-retarding effect described above is pH dependent (Jensén and Adalsteinsson, 1991) and Dutch experiments (Wever and Kipp, 1997) have shown that self-heating in peat-based growth substrate, as a consequense of accelerated microbial activity, can lead to a growth retarding response in plants. Wet conditions occurring during peat harvest are increasing the risk of self-heating, leading to a possible decline in peat quality.

The aim of this study was to elucidate the problems of peat quality which many Danish potted plant nurseries experienced in the course of 1999. In order to ensure proper communication between the industry and the scientists a joint project was initiated between the DEG Horticultural Advisory Service and the Department of Horticulture.

MATERIALS AND METHODS

We measured seed germination, shoot fresh weight, shoot dry weight, root growth, and the content of phenolic acids in 18 different peat samples delivered by Danish potted plant growers during the Fall 1999 and Winter 1999/2000. Of these samples the majority was products of mixed or unknown origin. Peat samples were categorized in the following way (the number in parenthesis is the number of samples in the category):

- Control - peat without any known problems (3).
- Peat of Lithuanian origin — no added fertilizers or lime (2).
- Peat where self-heating had occurred (2).
- Peat where problems had been identified in potted plant nurseries, samples taken prior to plant cultivation (8).
- Peat where problems had been identified in potted plant nurseries, samples taken after plant cultivation (3).

Compalox® is an activated aluminium oxide that can absorb polar compounds, as e.g., phenolic acids. Since peat contains a number of phenolic acids and some of these can have a potential toxic effect on plant growth, we mixed in 2 % (vol) Compalox® with a buffer effect of 0.5 mM P to a fraction of the 18 peat samples. The two treatments of every peat sample (± Compalox®) was placed on individual trays with separate irrigation systems. Germination was measured after 10 days and shoot growth was measured after 4 weeks in the five species used in the experiment: buckwheat (*Fagopyrum esculentum* Moench.), cress (*Lepidium sativum* L.), Chinese cabbage (*Brassica rapa* L. Pekinensis Group), lettuce (*Lactuca sativa* L.), and tomato (*Lycopersicon esculentum* Mill.). Five plants were sowed per pot in all species except cress where we sowed approximately 50 seeds per pot. There were five pots per species and per treatment. The plants were irrigated with a weak nutrient solution (EC 1.6, pH 6.0)

For chemical analyses approximately 2 liters of peat-based growing medium without Compalox® was air dried at room temperature. From each peat sample 50 g was used for further analysis. This sample was saponified with 300 ml 4 M NaOH for 24 h at room temperature and filtered. The pH of the filtrate was adjusted to pH < 2 with 4 M HCl and extracted with 100 ml ethyl acetate. The ethyl acetate phase, containing the hydrolyzed phenolic acids, was dried over anhydrous sodium sulfate (Na_2SO_4) and evaporated *in vacuo* at 30ºC. The residue was redissolved in 10 ml methanol and analyzed by analytical HPLC, using the method of Andreasen et al. (1999). So far we have identified ferulic acid and *p*-coumaric acid in the extracts which constitute up to 60% of the total amount of hydrolyzed phenolic acids.

RESULTS

Germination Test. The germination percentage in tomato was reduced significantly in the peat of Lithuanian origin which had not had added fertilizers and lime (Fig. 1). Addition of Compalox® had a strong positive effect on this peat category (Category 2). For the other peat categories there was only a slight positive effect of adding Compalox® (Fig. 1). The germination percentage was not significantly reduced in the samples of growing media where problems had been identified in potted plant nurseries (Category 4 and 5) compared to control (Category 1).The effect on germination percentage of adding Compalox® to the growing media was largest in tomato and chinese cabbage and less in the other species.

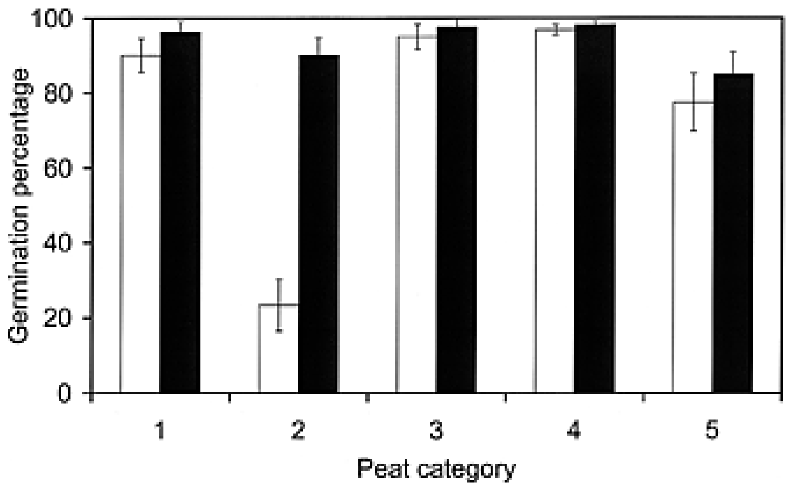

Figure 1. Germination percentage in tomato 10 days after sowing (five seeds per pot, five pots per treatment). (☐) Peat without Compalox®, (■) peat with Compalox®. See text for the detailed description of various peat categories.

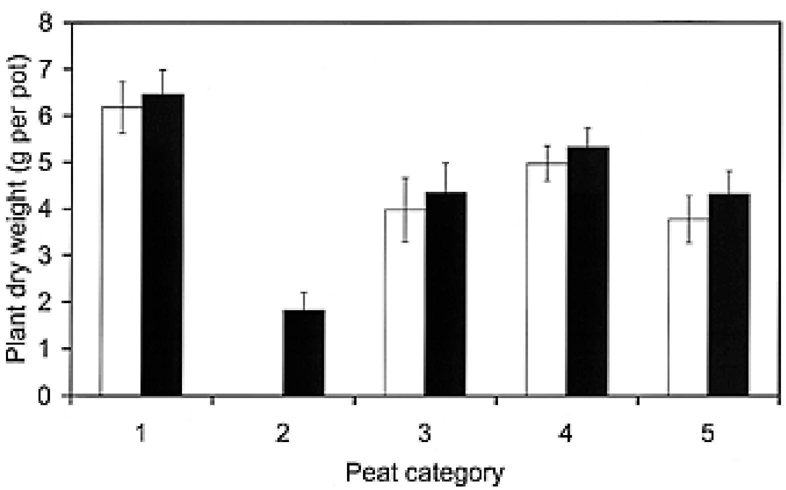

Figure 2. Plant dry weight in tomato 4 weeks after sowing. (☐) Peat without Compalox®, (■) peat with Compalox®. See text for a detailed description of various peat categories.

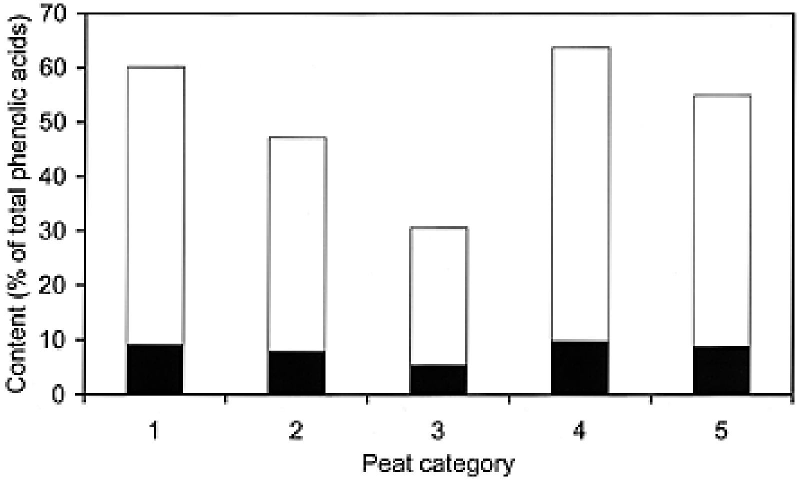

Figure 3. Content of the dominating phenolic acids, *p*-coumaric acid (□) and ferulic acid (■), shown as the percentage of all phenolic acids. See text for a detailed description of various peat categories.

Growth. Plant dry weight of tomato after 4 weeks of growth (Fig. 2) was largest in control peat without any known problems (Category 1). Growth was reduced significantly in the peat of Lithuanian origin which had not been added fertilizers and lime (Category 2). In peat of Categories 3, 4, and 5 growth was reduced significantly compared to Category 1 but less than in Category 2. There was a positive effect of adding Compalox® to all categories, although the largest effect was observed where the growth reduction was reduced the most (Category 2). There was a tendency that the peat of Lithuanian origin which had not been added fertilizers and lime had a lower pH than peat of Danish origin (pers. comm. Göran Larsson, Bara Mineraler AB, Sweden). Severe reductions in growth of all species tested was observed in this category compared to control. Addition of Compalox® partially solved this problem. Chinese cabbage was the species that showed the most significant response to low pH. In the samples of growing media where self-heating had occurred we observed that the problems diminished over time. In the samples of growing media where the problems had been identified in potted plant nurseries, the growth reduction was most severe in buckwheat and tomato, less in cress, and limited in lettuce and Chinese cabbage. Where plants had been grown in the samples prior to the test we observed a significant growth reduction, regardless of there had been identified quality problems in the nurseries.

Chemical Analyses. Peat where self-heating had occurred (Category 3) and peat of Lithuanian origin which had not been added fertilizers and lime (Category 2) had a reduced content of phenolic acids compared to control. The composition of phenolic acids (Fig. 3) was also different in peat from Categories 2 and 3. The percentage of the dominating phenolic acids (*p*-coumaric acid and ferulic acid) were lower in these two categories and consequently the relative content of other phenolic acids higher.

The other phenolic acids (apart from *p*-coumaric acid and ferulic acid) and organic acids have so far not been identified in these preliminary studies. Since the remaining acids have not yet been identified we can only speculate about their possible toxic effects. Peat where problems had been identified in potted plant nurseries, did not show significant differences in phenolic acid content and composition compared to control. This indicates that they had not been through a self-heating process. Based on growth analyses (Fig. 2) we observed a reduction in plant growth, which cannot be explained from nutrient availability, pH, or conductivity in the media (data not shown) or from the content and composition of the most common phenolic acids (*p*-coumaric acid and ferulic acid). A more detailed study of the content and toxicity of other phenolic and organic acids would be needed to get a better understanding of the processes in peat that can create quality problems in peat based growing media.

CONCLUSION

The germination tests did only identify problems with the peat of Lithuanian origin which had not been added fertilizers and lime (Category 2). Peat where self-heating had occurred and peat where problems had been identified in potted plant nurseries did not show significant changes in germination percentage. The method is therefore insufficient, and only catches a small fraction of the growing media with quality problems. We observed reduced growth where problems with the growing media had been identified in potted plant nurseries. Self-heating led to reduced growthand the composition and content of phenolic acids were different in these samples. In future work we would like to bring attention to the identification of specific phenolic acids, that have been found to have a potential toxic effect on plant growth and also extent this identification to other organic acids. In this respect we would like to analyse peat from various origin (e.g. Irish, Danish, Canadian, Lithuanian, and Finnish peat). These analyses will include mineral nutrients, phenolic acids and other organic acids. We find the observed differences in peat where self-heating had occurred very interesting and appearently detectable. The aim is to develop a test, that will reveal if self-heating has occurred in the peat. Furthermore we would like to test how aeration or drenching of the growing media affects the content and composition of potential toxic organic compounds in the media.

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