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Editorial

Optimising Soilless Culture Systems and Alternative Growing Media to Current Used Materials

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1. Introduction

In the last few decades, soilless culture systems (SCSs) have been gaining worldwide popularity, making them one of the fastest-growing sectors in agriculture [1,2]. As a result, there is increased interest in the production of seedlings and transplants and the growth of pot ornamentals, small/soft fruit crops, greens, herbs, and medicinal and aromatic plants in soilless container systems [3].

Growing media, i.e., crop cultivation in solid, inorganic, or organic materials, are relevant to efficient and intensive horticultural plant production within soilless systems. Therefore, today, horticultural science focuses on searching for alternative materials to peat, mineral wool, and other non-renewable raw materials. Thus, problems related to the despoiling of ecologically important peat bog areas, pervasive waste, and the sustainability of materials production, including transportation, have been moved to the forefront.

Currently, interest in organic production is continually increasing. However, the regulations that concern hydroponic production are different in different countries. For instance, EU rules do not allow plants grown hydroponically to be marketed as organic except when they grow naturally in water. This regulation applies to plants grown in aquaponics systems [4]. In contrast, the USDA organic regulations do not currently prohibit hydroponic production. Certification to the USDA organic standards is currently allowed if it is certifying to comply with the NOSB recommendations. However, which hydroponic practices align or do not align with the Organic Foods Production Act and USDA organic regulations is the subject of intense debate [5–7].

New strategies and technologies, including new sustainable raw materials, should be continually developed to solve specific cultivation limitations, optimise existing systems, reduce related environmental impacts, and address the impacts of climate change.

2. Special Issue Overview and a Short Discussion

Moving horticultural production from open fields to greenhouses means that all environmental conditions can be controlled better. The application of SCS means that conditions in the rootzone can also be controlled. After the reviewers' evaluation, nine original papers and one review from 41 authors from different countries were published in this Special Issue.

The focuses of the review papers included in this Special Issue were recent scientific evidence regarding the effects of several environmental and cultivation factors on the morphology, architecture, and performance of the root systems of plants grown in SCS. In this review, different issues were comprehensively discussed: the effect of root restriction, nutrient solution, irrigation frequency, rootzone temperature and pH, oxygenation, vapour pressure deficit, lighting, root exudates, CO_2, and beneficiary microorganisms [8].

One of the topics addressed in the current Special Issue was the optimisation of soilless culture systems. For instance, as ammonium is preferentially taken up, the rhizosphere of blueberry plants tends to become acidified over time [9]. The authors found that substrate amendment with low rates of $CaCO_3$ and fertigation with a low-pH nutrient solution (pH 4.5) are viable tools with which the pH buffering capacity can be increased in coconut coir-based substrates used for blueberry cultivation. $CaCO_3$ neutralised H^+ and contributed to Ca and Mg for plant uptake.

The application of organic fertilisation is complex because organic compounds first need to be mineralised. Cannavo et al. [10] reported that the release of mineral N is strongly dependent on the growing media, temperature, humidity, and fertiliser used. However, as the results described in this study were only derived from incubation trials, they should be additionally verified using plant experiments. Rhizosphere conditions and growing media properties influence the uptake of mineral elements.

Moreover, Loera-Muro et al. [7] recommended using vermicompost leachate fertiliser as a feasible replacement for inorganic fertiliser in hydroponic systems to achieve sustainable and eco-friendly agricultural production. The use of vermicompost leachate allows the maintenance of rosemary (*Rosmarinus officinalis* L.) or the increase in the production of mint (*Mentha spicata* L.) and with neither the modification of the bacterial communities for both plants nor changes to their ability to form biofilms. The product quality of both plants remained unaltered.

Avdouli et al. [11] investigated the performance of basil in a soilless culture cascade system. In such as system, the used nutrient solution drained from a primary crop is directed to a secondary crop, enhancing resource-use efficiency while minimising waste. The authors found that the performance of basil in the cascade system was subject to a compromise between a reduction in fresh produce and an increase in total amino acids and ascorbate content with an electric conductivity (EC) of 5 dS m^{-1} as the upper limit/threshold of tolerance to stress. They concluded that basil might be a good candidate for use as a secondary crop in a soilless culture cascade system.

The impacts of environmental issues and climate change required alternative peat materials in growing media. Peat is a limited resource in high demand, and the extraction of peat bogs has negative impacts on the environment. Covering only about 3% of Earth's land area, they may store nearly one-third of the entire world's terrestrial organic carbon [2,12]. In the long-term, peatlands are the largest stores of organic carbon out of all of the terrestrial ecosystems [13], i.e., they store more organic carbon than forests.

In the current Special Issue, different raw materials such as composts of spent mushrooms, composted heather, different coir types, alder, cattail, and reed were analysed as alternatives for the partial replacement of peat in growing media [14–16]. Hernández et al. [14] showed 3 to 7-times higher yields of red baby leaf lettuce compared to peat when composts from *Agaricus bisporus* and *Pleurotus ostreatus* were used, even under the pressure of the plant pathogen *Pythium irregulare*. The combinations of two compost types affected the higher suppressiveness of 50% against *Pythium*. Machado et al. [15] reported a high fresh yield and total flavonoids by cultivating spinach in coir pith. In contrast, the levels of other phytochemicals and antioxidant activity were not affected and remained within normal ranges for spinach. Moreover, Leiber-Sauheitl et al. [16] developed a preliminary test procedure for the identification of new raw materials as peat substitutes in growing media.

With sustainability in mind, the performance of greenhouse beit-alpha-cucumber in pine bark and perlite fertigated with biofloc aquaculture effluent was analysed [17]. In another study, hemp fibres were used to cultivate tomato plants as an organic alternative to mineral wool [18]. Hemp fibres led to similar yields to those achieved using conventionally used mineral wool. Likewise, no adverse effects on plant growth parameters and the quality of fruits were observed. Nevertheless, the authors reported low air volume and easily available water and very rapid microbial decomposition associated with high nitrogen immobilisation in hemp [18]. However, a question arises: what is the contribution of these changes and transformations of hemp during the cultivation on the total greenhouse gas emissions? The need to evaluate biological decomposition throughout the cultivation cycle should be considered for further research. At the same time, the greenhouse gas emissions should be calculated from the production of the material until its disposal. For instance, mineral wool has a high energy demand associated with the expansion of the minerals during the manufacturing process with disposal problems. At the same time, hemp is a renewable material that can be composted at the end of cultivation.

3. Conclusions

This Special Issue provides insight into the optimisation of the existing SCS. Furthermore, it contributes to an extension of the research that concerns finding and utilising novel alternative raw materials to those currently preparing sustainable growing media.

It is clear that while much has been achieved in this Special Issue, many challenges remain. The use of new, practical, and effective tools and technologies in SCS and the continuous pursuit and validation of novel and renewable soilless substrate materials may assist in solving some of the challenges in a climate-smart agriculture approach and dealing with the environmental problems in soilless cropping. We expect these publications to promote further discussion about these two exciting topics.

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