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Optimizing the Physical and Nutritional Environment of Closed Root-Zones

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Abstract:

A closed root-zone is defined as one without the luxury of leaching. The objective of this study is to optimize the physical and nutritional components, media and fertilizer, respectively, of such a system. Among the many characteristics of an appropriate media is high cation exchange capacity (CEC), to buffer nutrient availability to plants. Peat-based media have more than 400 percent the CEC of ceramic media. Another important media characteristic is the plant-available elements that exist on the media “out of the bag.” Ceramic media was found to contain large amounts of manganese which was taken up by plants at toxic levels. For optimization of the nutritional environment, polymer-coated fertilizer (PCF) is a class of controlled-release fertilizer, the ultimate goal of which is to match fertilizer release with plant uptake, contributing to optimal plant growth, with no nutrient-leaching losses, and minimal grower input. However, there is considerable variability in release trends among the various forms of PCF. Among the brands tested, Osmocote, Nutricote, and Polyon, Nutricote was found to have to most appropriate nutrient-release characteristics for use in a closed system.

Objective:

The optimization of the physical and nutritional components of a closed root-zone environment, with a single input of fertilizer and media, and no leaching, to sustain productive plant growth over time.

Nutritional Environment: Polymer-Coated Fertilizers (PCF)

A study was conducted to characterize the nutrient release trends and variability of three forms of PCF: 12-14 month Osmocote 15-9-12, type 270 Nutricote 18-6-8, and 10-12 month Polyon 15-6-11. It was found that Osmocote has a large initial release of nutrients, followed by a decreasing trend in nutrient release over time; Nutricote maintained a single, consistent rate of nutrient release over time; and Polyon had a very low initial release, followed by a consistent, peak rate. Variability in release decreased over time for all PCF.

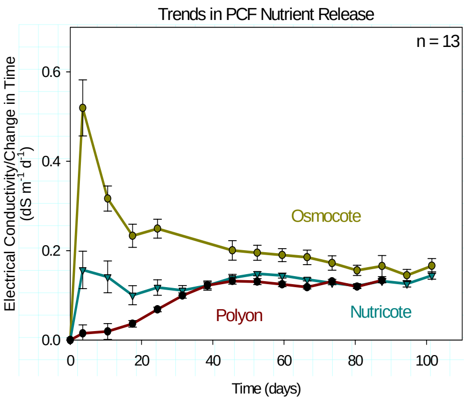

Figure 1: The nutrient release rates of Osmocote, Nutricote, and Polyon, tracked by rise in electrical conductivity in 200 ml water.

Figure 2: Flasks of Osmocote, Nutricote, and Polyon PCF in deionized water for measurement of electrical conductivity.

The Physical Environment: Media

The properties of media play a large role in the success of plant growth in closed systems. The cation exchange capacity of media buffers nutrient balance, “soaking up” nutrients in excess and releasing them when deficient. Out of the bag, media contain nutrients that go into solution and become plant-available, potentially good or bad. An example of this is toxic levels of Manganese in ceramic media. Finally, media differ in their plant-available water-holding capacity, which makes the margin in which water in those media is at appropriate levels more or less narrow.

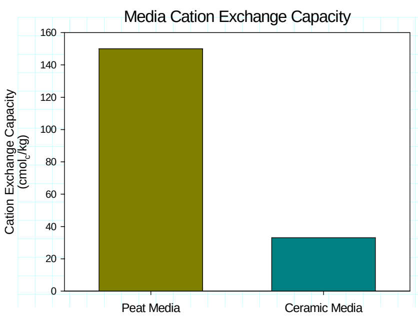

Figure 3: Cation exchange capacity (CEC) of two plant-growth media.

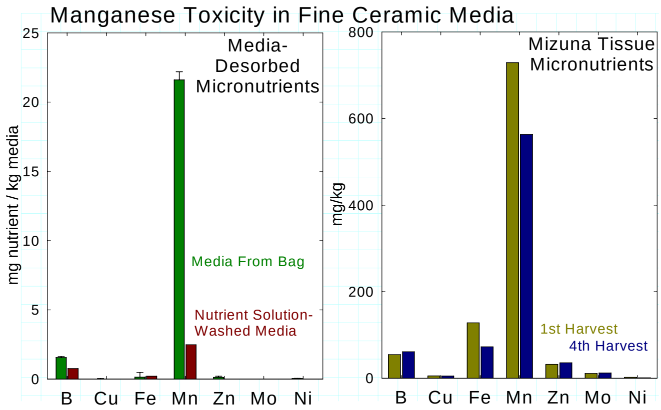

Figure 4: Left: Micronutrients desorbed from fine ceramic media, out of the bag and after washing with nutrient solution. Right: Micronutrient concentrations in tissue of Mizuna grown in fine ceramic media.

Figure 5: White spots on leaves of Mizuna as a result of uptake of manganese at toxic levels from fine ceramic media.

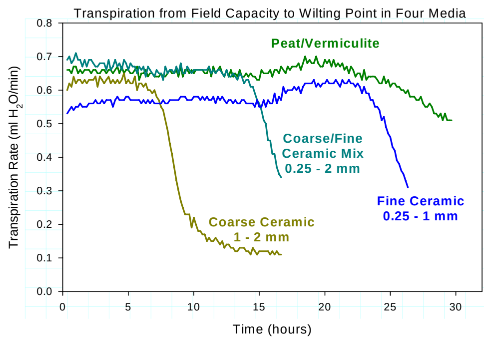

Figure 6: Evapotranspiration of potted plants in four media over time. The pots were at field capacity at t = 0 and no water was added.

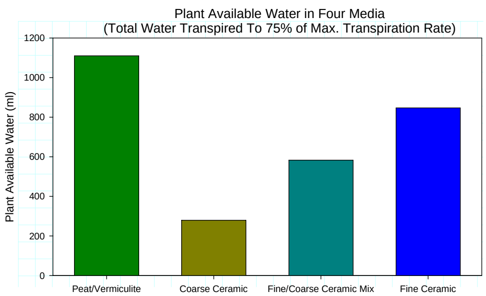

Figure 7: Plant-available water in four media, derived from transpiration graph above as total water transpired from field capacity (t = 0) to the point when transpiration rate fell to 75% of the maximum rate.

Discussion:

Among the brands of PCF tested, our results have shown that Nutricote has the most consistent release of nutrients over time. In a closed system, this more consistent release is important to prevent nutrients from becoming limiting or causing salt stress. Polyon takes weeks to ramp up to its peak rate, but then maintains a very consistent rate. Osmocote releases nutrients in an inconsistent pattern that does not match plant-uptake. Among the media analyzed, peat has the highest CEC, the highest plant-available water holding capacity, and does not carry toxic levels of detrimental elements. Ceramic media was found to contain toxic levels of Manganese, has reasonable water-holding capacity if fine, and has a relatively low CEC. Washing can help remove excess elements from ceramic media.

References:

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