Polymer-Coated Fertilizer Application Rate Modeling based on Phosphorus

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Abstract

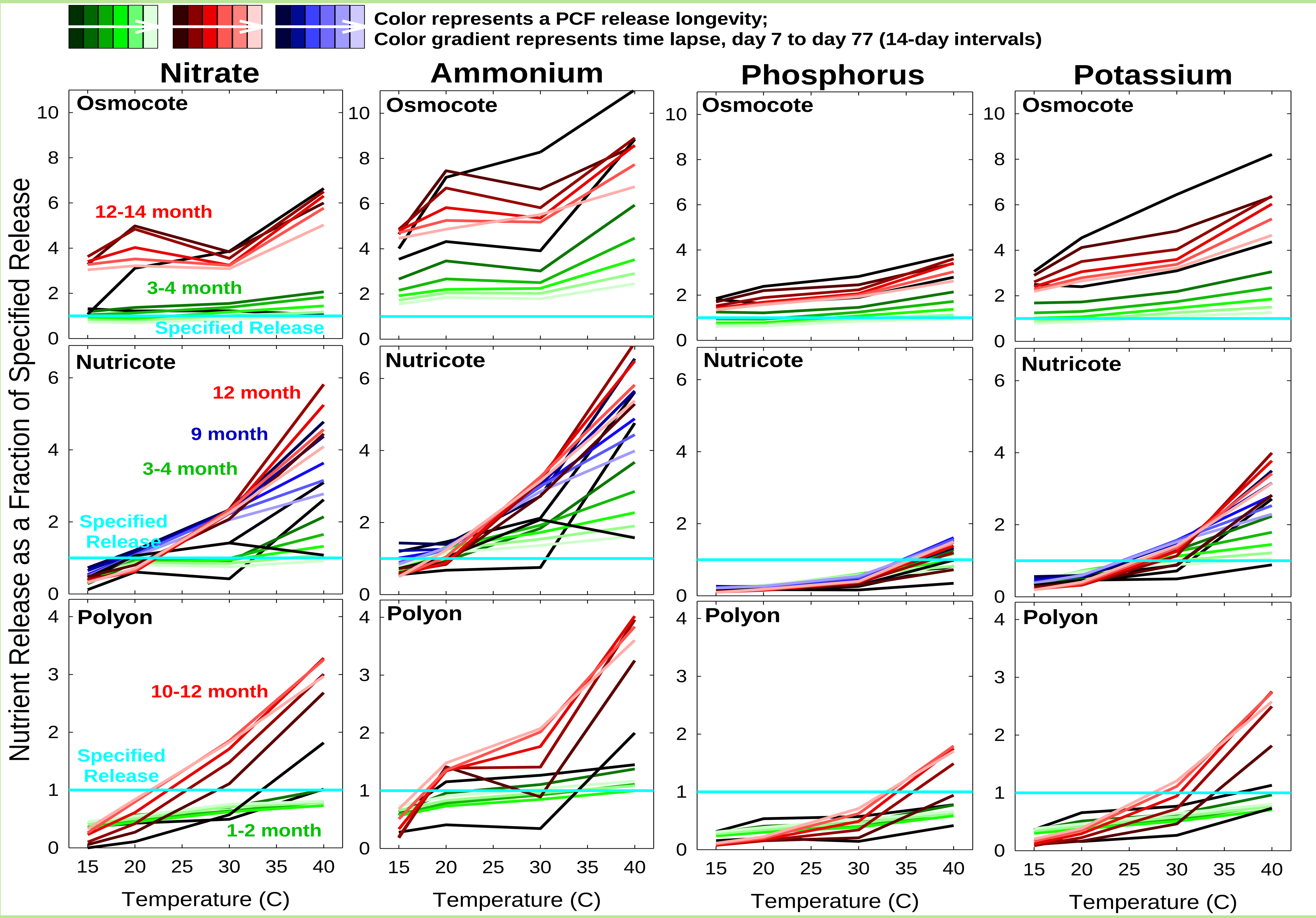
Polymer-coated fertilizers (PCF) are designed to increase nutrient-use efficiency by coating nutrients to provide a regulated availability. No comprehensive model has been developed that couples models to predict plant growth and PCF nutrient release rates. We present a plant growth model based on incoming photosynthetic photon flux (PPF) and the efficiency of four plant-growth determinants. We also present a model to predict PCF ion release rates. This model is based on the finding that, among macronutrients, phosphorus is released at the slowest relative rate from PCF, and is thus the limiting nutrient to plant growth. PCF application rates are adjusted by empirically derived equations that describe the cumulative release of phosphorus as a function of temperature relative to the prescribed release for a given PCF. The efficacy of the model to accurately predict PCF application rates was verified with a growth trial. Plant growth, in the growth trial, matched the growth predicted by the model; and peak growth occurred at a PCF application rate that matched the predicted application rate. This result suggests that this modeling approach has potential to provide a basis for determining optimum PCF application rates when the fertilizer release rate has been characterized.

Objectives

To accurately model plant growth and PCF nutrient release rates, for prediction of optimal PCF application rates.

Actual versus Specified Release of NO_3^-, NH_4^+, P, and K with Temperature

We tested nutrient release of Polyon, Nutricote, and Osmocote PCF products. In all three PCF types, nutrients were released in the following relative order: Ammonium > Nitrate > Potassium > Phosphorus. Since plants take up the macronutrients in concentrations orders of magnitude greater than the micronutrients, this trend makes PCF-fertilized plants limited by phosphorus. This consistent trend among PCF was thus used as the basis for our model of nutrient release.

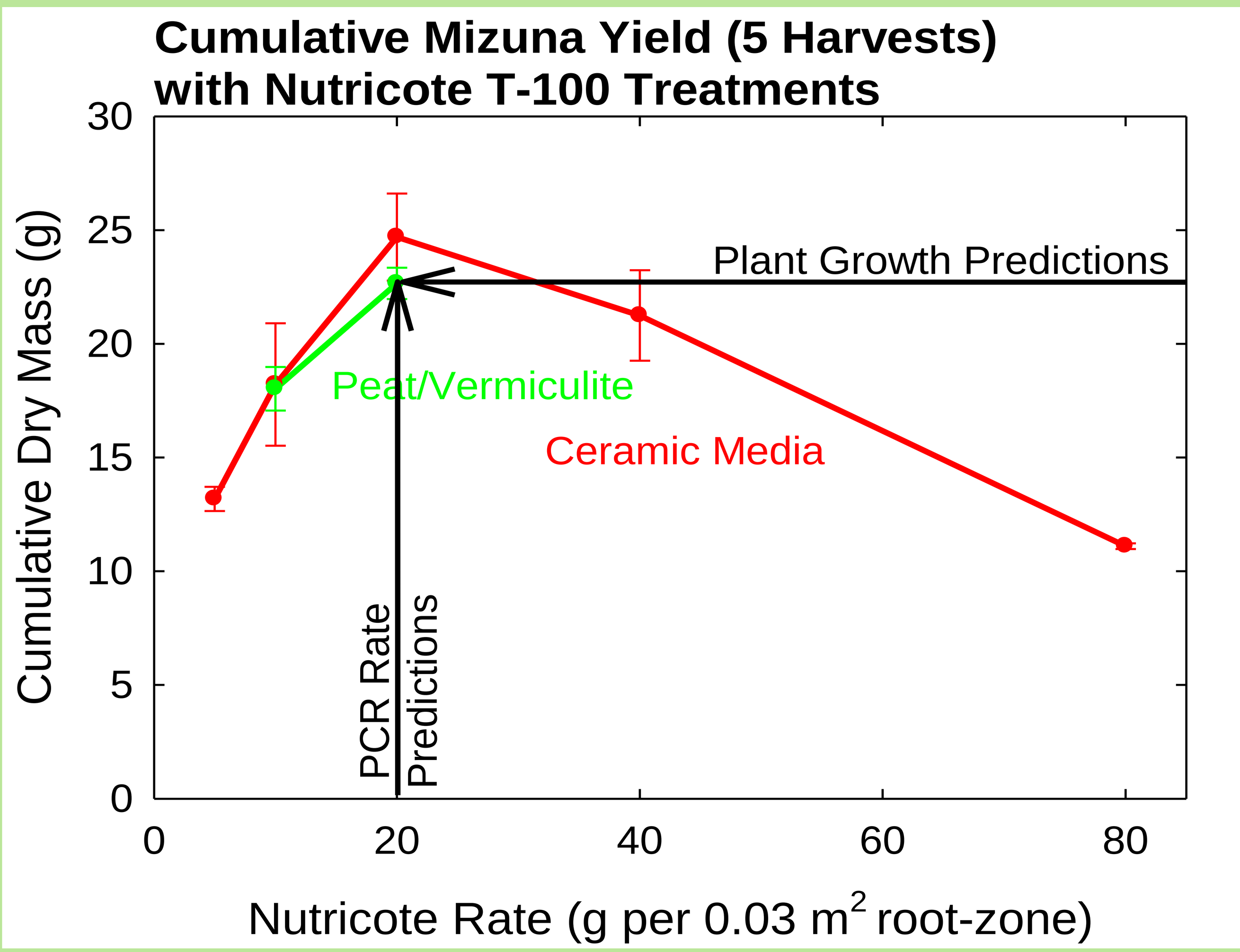


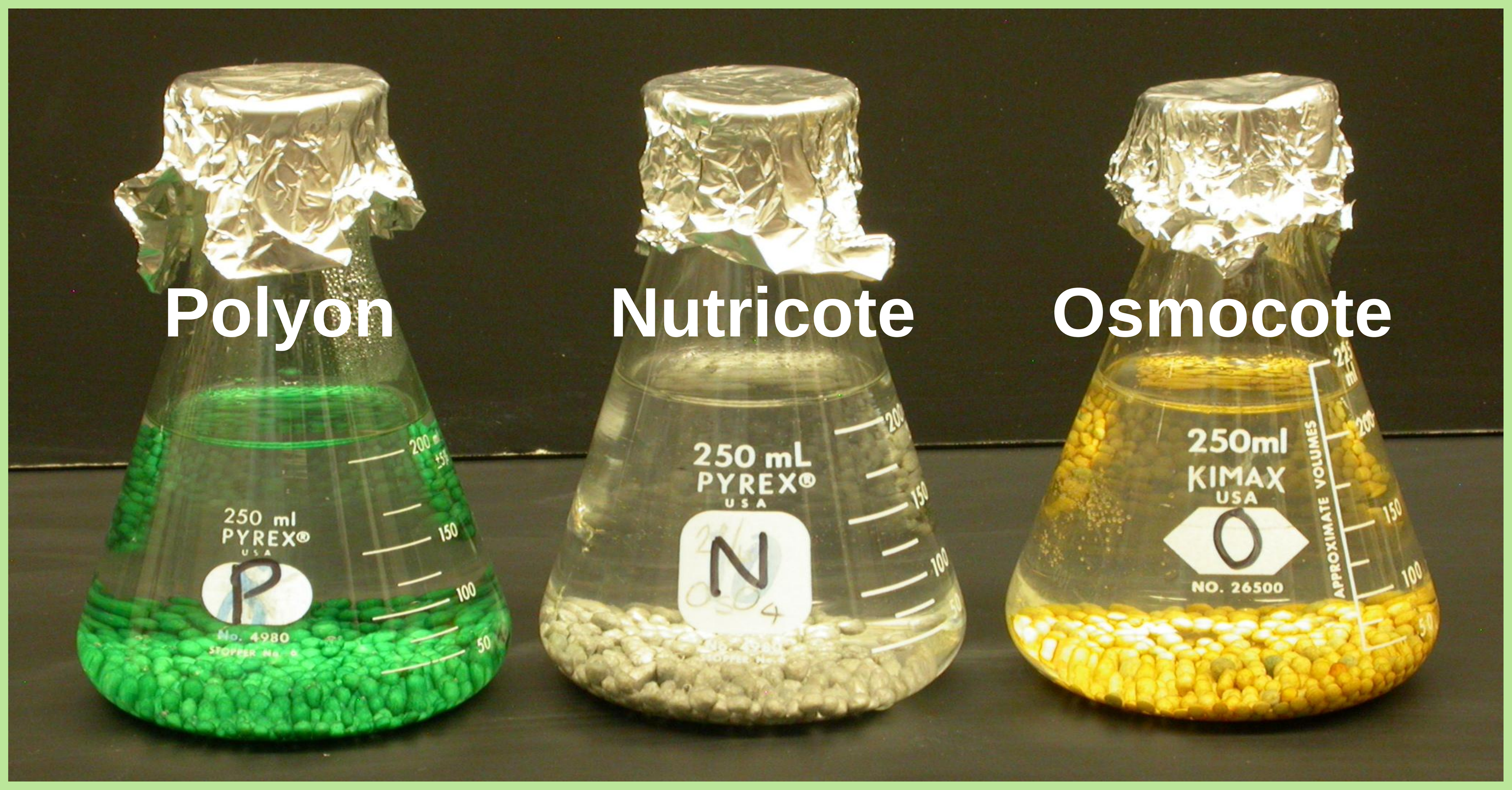
Model Variables & Verification of the Model

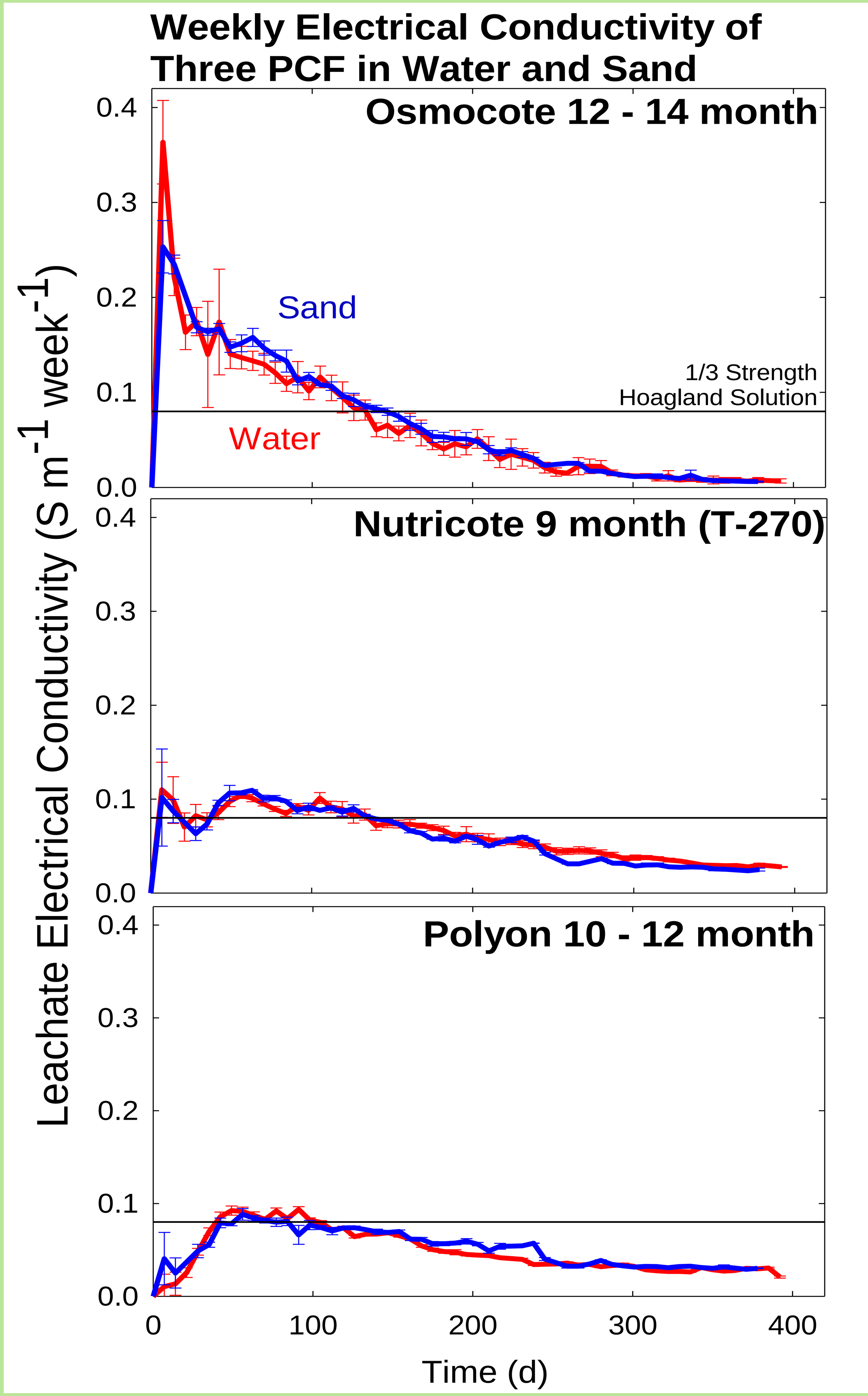
A growth trial (results to the right) verified that our modeling approach predicted the cumulative dry mass at harvest and the optimal PCF application rate.

Model Variables (Determined by grower)

Plant Growth Model	Nutrient Release Model
PPF	Plant P Concentration
Plant Capture of PPF	Stated PCF P Content
Growth Period	Temperature







PCF Selection

Osmocote, Nutricote, and Polyon (three widely used PCF types) vary greatly in nutrient release characteristics. In a generalized sense, Osmocote quickly released nutrients, with a sharply declining trend in nutrient release over time; Polyon had a slower release, ramping up to its peak over about 50 days; and Nutricote had the most consistent release of the PCF tested. Choosing an appropriate PCF is important in optimization of nutrient supply.

References

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