MODELING WATER UPTAKE BY TURFGRASS FOR A USGA ROOT ZONE MODIFIED WITH INORGANIC AMENDMENTS

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ABSTRACT

Water uptake by roots plays an important physiological role in crop growth. Through water uptake by roots, translocation and eventually water loss by transpiration, plants regulate temperature, while water and chemicals, including nutrients move into the soil-water-plant system. The objective of this study was to model water movement with uptake by plant roots for a USGA sand-based root zone modified with inorganic amendments, viz., calcined diatomaceous earth (Axis and Isolite), zeolites (Clinolite and Ecolite), and calcined clays (Moltan Plus, Profile, and Pro's Choice). A numerical model was applied to simulate a scenario with (15% amendment plus 85% sand v/v) and without amendment incorporation (100% sand). The simulation results showed reduced surface dryness, higher volumetric water content and storage, and higher initial root water uptake rate for the root zones modified with amendments. The highest simulated water storage was observed for root zones modified with calcined diatomaceous earths especially the Axis amendment.

INTRODUCTION

The United States Golf Association (USGA) has provided specifications for root zone construction for golf putting greens, which are composed predominantly of sand mixed with a relatively small amount of organic material, typically peat (Kussow, 1987). Addition of organic amendments increase water and nutrient retention, but they decompose over time reducing porosity. In recent years there has been a trend towards use of inorganic amendments and these are more resistant to decomposition. However, there is insufficient information on water movement with uptake by plant roots for USGA sand-based root zones modified with inorganic amendments. This study involved the use use of a numerical model, HYDRUS 1-D (Simunek et al., 1998) to simulate water movement with uptake by plant roots for USGA-specific root zone modified with inorganic amendments.

OBJECTIVES

- To model water movement with uptake by plant roots for a USGA sand-based root zone modified with inorganic amendments.
- To compare scenarios with and without amendment incorporation.

METHODS AND MATERIALS

- Seven amendments, viz., Axis, Isolite, Clinolite, Ecolite, Moltan Plus, Profile, and Pro's Choice were used in this study.
- The amendments were mixed with sand at 15% amendment and 85% sand (v/v) as suggested by USGA for amending sand-based root zones.
- Water retention (WR) was determined for the amendment-sand mixtures and for non-amended sand using Tempe pressure cells (Dane and Hopmans, 2002) and ceramic plate extractor (Fig. 1).
- The WR data (pressure head versus volumetric water content) were fitted to the van Genuchten (van Genuchten, 1980) model:

$$S_e = \frac{\theta-\theta_r}{\theta_s-\theta_r} = \left[\frac{1}{1+(\alpha|h_m|)N}\right]^M \qquad M = 1-1/N, \qquad N > 1$$

where S_e is the effective water content, θ the volumetric water content, θ_r the residual volumetric water content, θ_s the saturated volumetric water content, h_m is the matric head (cm), and α, M, and N are curve fitting parameters.

- The van Genuchten parameters were incorporated in HYDDRUS 1-D model to simulate water movement for a USGA-specific sand-based root zone (Fig. 2).
- Simulation results for non-amended and amended sand were compared. We have presented the results for one calcined diatomaceous earth (Axis) amendment.

Fig. 1 a. Tempe (pressure) cells

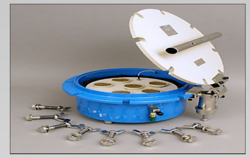

Fig. 1 b. Ceramic Plate extractor

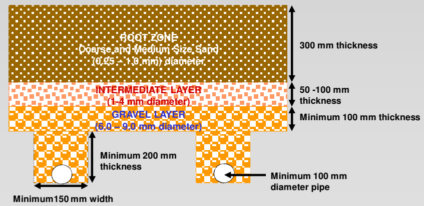

Fig. 2. The USGA-specific sand-based root zone

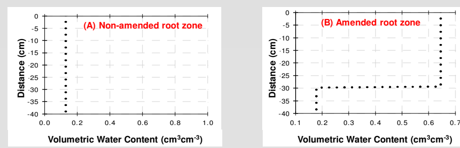

Fig. 3. Volumetric water content for a 10-day simulation period for (A) Non-amended and (B) Amended root zone.

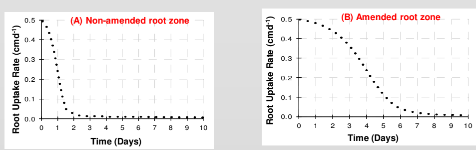

Fig. 4. Root water uptake rate for a 10-day simulation period for (A) Non-amended and (B) Amended root zone.

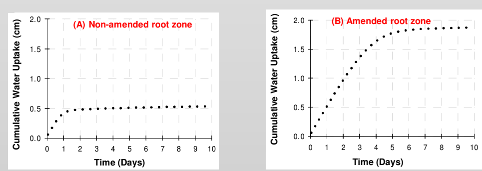

Fig. 5. Cum. root water uptake rate for a 10-day simulation period for (A) Non-amended and (B) Amended root zone.

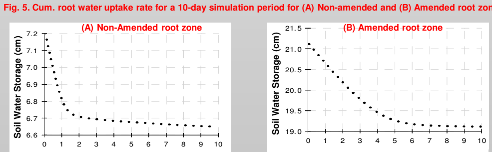

Fig. 6. Soil water storage for a 10-day simulation period for (A) Non-amended and (B) Amended root zone.

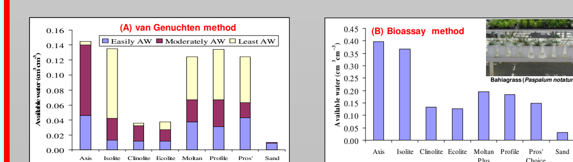

Fig. 7. Available water determined by (A) van Genuchten parameters and (B) bioassay method.

RESULTS AND DISCUSSIONS

- The results show lower volumetric water content for the non-amended root zone (0.18 cm^3cm^{-3}) compared to the amended (0.62 cm^3cm^{-3}) (Fig. 3).
- The root water uptake rate was found to decrease with time for the entire 10-day simulation period (Fig. 4).
- The initial root water uptake rate was 0.5 cmd^{-1} and this reduced to 0.02 cmd^{-1} at the end of simulation period.
- For the non-amended root zone the reduction to the minimum occurred just after 2 days compared to 7 days for the amended root zone.
- The cumulative root water uptake at the end of simulation period is about 0.5 cm for the non-amended root zone while it is 1.8 cm for the amended (Fig. 5).
- The results for the water storage in the soil profile for the non-amended profile show initial water storage of 7.2 cm which decreases to 6.6 cm after 10-day simulation period.
- For the amended profile the initial water storage is 21.2 cm, decreasing to 19.0 cm after 10 days (Fig. 6).
- The available water values determined using the van Genuchten model showed a similar trend but lower values than those determined using a bioassay method (Fig. 7).
- These findings suggest that inorganic amendments hold water in pores that is not extruded using the Tempe Cell-pressure cell method, but which is accessible to plant roots.
- Calcined diatomaceous earths showed comparatively superior hydraulic characteristics including water retention and available water, with Axis showing the best properties.

CONCLUSIONS

- The results obtained show that incorporation of inorganic amendments increases volumetric water content, root water uptake and greater root zone water storage.
- Calcined diatomaceous earth showed the highest volumetric water content, highest root water uptake and root zone water storage.

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