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A greener green industry

A research team studies ways to improve water and nutrient retention while capturing and recycling excess runoff

By Sarah White, Jim Owen, and Chris Wilson

The emphasis on sustainable practices is expanding in every sector of the U.S., from businesses to individual homeowners. Everyone is looking for ways to increase profitability (or enjoyment) while minimizing their "eco-footprint."

The nursery industry's role in this movement involves balancing increased resource-use efficiency with minimal environmental impact. By controlling onsite and offsite movement of nutrients, pesticides, and water, nurseries can become sustainable operations that are part of the larger movement stressing the importance of satisfying the "needs of the present without compromising the needs of future generations."

A joint effort of the USDA Floriculture and Research Initiative and the American Nursery and Landscape Association resulted in the formation of a research team representing four universities and two USDA-ARS locations, focusing on water quality and water conservation issues of nursery operations.

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In a study, scientists evaluated the efficacy of bark substrates with and without clay or sand added using four taxa.

The broad objectives of this water project are to develop economically feasible production systems and management practices that promote water conservation and protect water quality while sustaining or improving crop quality, production efficiency, and profitability.

Specific objectives include: 1) improving water and nutrient retention in container production, 2) capturing and recycling runoff, and 3) remediation of runoff containing excess nutrient and residual pesticides prior to offsite discharge.

Combined, the work of each researcher involved helps to refine a whole-system approach to sustainability and environmental resource management. It illustrates the interactions among each aspect of nursery management, from water and fertilizer application to managing runoff leaving the nursery.

A value-added amendment

Bark is the dominant component of soilless substrate mixes throughout the United States because it has been an inexpensive, stable, and readily-available product that provides good aeration with no plant toxicity.

However, bark-based mixes retain little water and nutrients, usually resulting in low plant water and nutrient use efficiency. In typical production

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The fast growth habit and large biomass of *Thalia* contribute to its ability to filter excess phosphorus from runoff.

systems using bark-based mixes, the plant uses less than 50 percent of water and nutrients applied by the grower.

An improved container mix, able to retain water and nutrients while providing adequate aeration would greatly enhance the nursery industry's sustainability efforts and pocket books.

Calcined clays (clay minerals fired to very high temperatures to yield an absorbent, stable granular material) could be adopted as alternatives to sand or pumice in bark-based container mixes.

Studies were conducted to examine the incorporation of a calcined clay amendment into pine bark-based container mixes using *Cotoneaster dammeri* C.K. Schneid. 'Skogholm' potted in trade 5-gallon containers.

Water availability of the soilless substrate mix increased 4 percent or 17 ounces per 5-gallon container when pine bark was amended (11 percent by vol.) with clay versus sand. This increased water storage or buffering capacity in 8-to-1 pine bark-to-clay substrate resulted in established plants not wilting for an additional 48 hours when unwatered.

In addition, compared with an 8-to-1 bark-to-sand mix, the clay-amended bark mix reduced water use by 6 gallons of water per 5-gallon container, or 200,000 gallons per acre, per season. This reduced application of water also significantly decreased phosphorus leaching by 60 percent without sacrificing plant growth

Plant content of all macronutrients (phosphorus, potassium, calcium, and magnesium) except nitrogen, increased with clay-amended bark compared with sand amended bark. Clay-amended substrates were both able to retain fertilizer phosphorus and provide phosphorus (native to the clay), therefore decreasing phosphate leaching or resulting in no need for addition of fertilizer phosphorus, respectively.

We suggest that a fertilizer analysis be preformed on each clay lot or batch to determine its chemical content. Fertilizer rates can then be adjusted as needed.

Calcined clays as amendments in pine bark-based substrates can reduce water loss from containers, act as a slow release source of phosphorus, reduce environmental impacts, and deliver sufficient water and nutrients for high quality container production.

Experimental nitrate removal

Smaller nurseries, and those in areas where land is limited or expensive, cannot practically dedicate land area to non-production uses, such as constructed wetlands for remediation. The ideal water treatment system for these cases is one incorporated into the nursery landscape without sacrificing production area.

This type of system could capture and treat drainage water close to individual production areas, and could be incorporated beneath roadways, plant-holding areas, or any other area used for production purposes.

The experimental, small-scale nitrate removal system developed at UF/IFAS relies on native microorganisms to convert nitrate-nitrogen in water to nitrogen gas, which is released into the atmosphere (denitrification).

Establishment and maintenance of an optimal community of microorganisms requires low-oxygen conditions and a continuous supply of nitrate and carbon. Kaldness media, a slightly buoyant material used in the aquaculture industry, provides surface area (256 square feet per cubic foot of media) for anchoring the microorganisms, and porosity to allow adequate flow rates.

This nitrate removal system requires intensive management, relative to

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constructed wetland systems, to achieve optimal removal efficiencies. For a successful nitrate treatment system, the nursery operator needs to accurately estimate expected nitrate loadings/concentrations from production areas and typical runoff flow rates/volumes. In addition, they must allocate system management resources (materials and labor) for optimal nitrate removal efficiency.

Small-scale lab and field studies at a commercial foliage plant nursery have shown greater than 90 percent nitrate removal rate in a flow-through system with residence time of less than 30 minutes (flow rate approximately 2.6 gallons per minute).

While this system seems to be very promising, uncertainty exists regarding the impact of pesticides on the functioning of the microorganisms. This is currently being evaluated.

Constructed wetland systems

Successful nursery production depends on fertilizers and other agrochemicals such as growth regulators and pesticides.

Currently, only pesticide use and disposal is regulated; however, many believe that state and federal environmental agencies will likely enact stricter water quality standards in the near future. New water quality goals would change how nurseries manage irrigation and runoff, as nursery producers would have to consider both fertilizer presence and pesticides.

Constructed wetland systems (CWS) work best for high to moderate runoff volumes, where land is both available and affordable.

Nitrogen (nitrate, nitrite, and ammonia) removal in CWS is highly efficient, with greater than 90 percent removal efficiency from mid-spring through late fall. Efficiency declines during winter months, but substantial nitrogen removal continues even then. Constructed wetland systems should be large enough to retain water for 3 to 3.5 days.

"New water quality goals would change how nurseries manage irrigation and runoff."

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Phosphorus removal efficiency is more variable, and simply passing water through a CWS will not adequately reduce levels. Additional action is necessary. From the production side, nurseries can incorporate fired clays into bark-based mixes, reduce phosphorus levels in soil mixes, and use low-phosphorus fertilizers in liquid feeding programs. From the remediation end, they can incorporate phosphorus "hyper-accumulators" in CWS. Some species show potential for removing excess phosphorus from runoff. These include *Canna* 'Bengal Tiger,' *Pontederia cordata* 'Singapore Pink,' and *Thalia geniculata* f. *rheumoides.*

Nurseries should include a secondary, subsurface flow, phosphorus treatment cell, where discharge from the primary CWS flows through fired-clay nuggets (e.g. calcined clay) and remains in contact with them for at least 1.25 days.

Phosphorus attaches to "binding sites" within these clay nuggets. The removal efficiency declines as binding sites fill, so monitoring is necessary to determine when the nuggets need to be replaced. These secondary treatments can be greater than 80 percent efficient in reducing phosphorus concentrations in discharge.

Conclusions

Using calcined clays in pine bark-based container mixes is a simple practice to reduce the environmental impacts associated with containerized nursery production, and reduces the need for constructed wetlands or other strategies to manage nursery runoff.

A cost-benefit analysis should be used to determine when the small-scale nitrate removal system is feasible for a specific nursery, or whether alternative treatment methods are necessary.

Constructed wetland systems are efficient at nutrient removal if designed correctly and if adequate monitoring (bi-monthly) is performed. Additional research into the utility of additional fired-clay substrates as amendments to bark-based media would be useful.

Also examination of phosphorus-saturated clay from secondary wetlands as a media amendment and phosphorus fertilizer source should be examined to determine if the dual use of clay substrate could reduce loss of phosphorus from pots and reduce money spent on fertilizers. ©

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