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Nitrogen Management in Nursery Production

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Summary

Many years of nitrogen fertilizer use have resulted in nitrate contamination of groundwater in the Central Valley of California, prompting the introduction of the Irrigation and Nitrogen Management Plan (INMP) in 2019. This plan aims to track nitrogen inputs and outputs, estimating potentially leachable nitrogen not removed by the harvested product. Estimating nitrogen output is challenging for nursery crops due to complex production systems. We conducted an experiment to assess nitrogen fate in container-grown *Lagerstroemia indica* plants. Our results showed that 61% of applied nitrogen was retained in the plant or media, while 28% was lost as gaseous emissions and only 6% as runoff. Importantly, just 3% of nitrogen was potentially leachable, far lower than INMP estimates. A separate study on CRF incorporation revealed that mechanical incorporation of Osmocote Plus 15-9-12 into the media resulted in higher nitrogen leaching compared to manual incorporation, likely due to prill coating damage. These findings suggest that INMP calculations overestimate nitrogen leaching from nursery crops, underscoring the need for targeted best management practices. The adoption of CRF incorporation methods that minimize leaching could further reduce nitrogen contamination, making best practices more effective than rigid reporting requirements for nursery operations.

INTRODUCTION

Many years of nitrogen fertilizer application has led to nitrate-contaminated groundwater in large portions of the Central Valley of California. In 2014, this contamination led the Central Valley Regional Water Quality Control Board to require plant producers to submit Nitrogen Management Plans to their water quality coalitions. In 2019, the original Nitrogen Management Plan was replaced by the newer Irrigation and Nitrogen Management Plan (INMP) that also included irrigation management information. The INMP is a balance sheet that reports nitrogen inputs from fertilizer, irrigation water, and container media and output from the harvested product. Total nitrogen output is subtracted from total nitrogen input to estimate total potentially leachable nitrogen.

The idea behind potentially leachable nitrogen is that any applied nitrogen not removed in the harvested product has the possibility to leach into groundwater. Estimating harvested nitrogen is straightforward for a crop like almonds because 136 pounds of nitrogen is removed for every one ton of almonds harvested. As nursery growers will recognize, estimating harvested nitrogen is not as straightforward for nursery crops due to the complex production system and variety of plant taxa and sizes grown at a single location. Possible fates of applied nitrogen to nursery crops include plant uptake, leachate from the container media, remaining in the container media, or possibly emitted as nitrogen gas from denitrification. We initiated an experiment to determine the fate of fertilizer nitrogen and answer the real question the Central Valley Regional Water Quality Control Board was asking, "How much nitrogen leaches from container-grown plant nurseries?"

MATERIALS AND METHODS

We collaborated with a nursery in the Central Valley of California to document nitrogen input and output during production of *Lagerstroemia indica* "Whitt II" plants grown in a Douglas-fir bark media incorporated with Osmocote Plus (15-9-12) and Apex polymer-coated sulfur-coated urea (9-2-0). Plants were transplanted from a #1 container into a #3 container in the beginning of May. On the third day after planting, the growing media was top-dressed with 20-9-9 fertilizer. We measured all nitrogen inputs, including well water applied as irrigation, total nitrogen in the growing media, and surface-applied fertilizer. Nitrogen outputs included shoot uptake; amount remaining in growing media at harvest time; nitrogen gas emitted; and soluble nitrogen in leachate/runoff.

To capture runoff nitrogen, we lined half of the growing beds in the test area with polyethylene sheeting sandwiched between sediment fabric before covering all the beds with gravel. The total nitrogen that infiltrated into the growing bed soil was the difference in the nitrogen in the runoff from the lined and unlined growing beds. After approximately three months, we harvested the plants when the grower was ready to ship them for retail sale. We cut the shoots off at the crown of the harvested plants and measured the total nitrogen in the shoots and growing media separately.

RESULTS

We determined that 61% of the applied nitrogen was in the plant or media when the plants were ready for shipping. Five percent of applied nitrogen was taken up by the plant shoots and 56% remained in the media as controlled-release fertilizer or as organic nitrogen in plant roots or immobilized by microbes. Maintaining a fertilizer nitrogen reserve in the growing media ensures that the plants will remain healthy and attractive while awaiting purchase by home gardeners or landscapers. Six percent of the applied nitrogen was in the growing bed runoff water, predominantly as nitrate. Irrigation runoff water capturing and recycling is common in California nursery production and the nitrogen in runoff water could reduce future fertilizer application costs. In agreement with other nitrogen balance research from container-plant production systems, 28% of applied nitrogen was lost as gaseous nitrogen emissions from denitrification.

DISCUSSION

The question the INMP calculations were supposed to answer is how much nitrogen is leaching into the soil and potentially contaminating groundwater. If harvested nitrogen from a *Lagerstroemia indica* production system was documented in the INMP by a grower, then 61% of applied nitrogen would be used as output in the calculations. This results in 39% of applied nitrogen deemed potentially leachable by the INMP worksheet, when our research results recorded that a mere 3% was potentially leachable. These results indicate that the INMP worksheets and calculations overestimated the amount of potentially leachable nitrogen from container-plant production. Three percent of applied nitrogen is equal to 20 lbs. per acre and coupled with the comparatively small total area of nursery production relative to other crops in the Central Valley, it is unlikely that nursery production is a significant contributor to nitrate contamination of groundwater in the Central Valley. However, areas with a high density of nursery producers could result in localized nitrate contamination of groundwater.

These results are becoming more significant because all Regional Water Quality Control Boards are requiring nitrogen management reporting plans. Some areas have large concentrations of nursery growers. Nurseries would have to conduct studies similar to our research to develop nitrogen input and output values to accurately fill out the INMP worksheet. Due to the large variety of plant taxa and sizes grown and different fertilizer programs, a significant and possibly debilitating cost could be incurred. Therefore, instead of requiring INMPs for nurseries, California's Regional Water Quality Control Boards should facilitate implementation of irrigation and nitrogen best management practices at nurseries to reduce potentially leachable nitrogen. Numerous best management practice guides exist and consultation with University of California Cooperative Extension Advisors could further facilitate implementation.

Uniform incorporation of controlled-release fertilizer (CRF) is a recommended best management practice to reduce nitrogen leaching losses from container-plant production. The potential for damage to CRF prill coating when mechanically incorporated into a soilless substrate was tested. Osmocote Plus 15-9-12 was uniformly incorporated mechanically or manually at the same rate into a soilless substrate and leachate was collected over 76 days. Two experiments were conducted.

One experiment included lavender plants planted into soilless substrate, the other experiment did not. Leachate volume, electrical conductivity (EC), and pH were recorded. Aliquots were later analyzed for inorganic nitrogen content. Electrical conductivity and leachate volume were used to calculate total salt content. Greater total salts, ammonium, and nitrate were leached from mechanically incorporated soilless substrate with and without plants relative to manually incorporated soilless substrate with and without plants. Plants grown in soilless substrate with mechanically incorporated CRF did not have decreased plant shoot biomass even though leachate EC was consistently greater throughout the experiment. Mechanically incorporating CRF in soilless substrate results in greater leaching losses and is likely a result of CRF prill coating damage during incorporation.

Researchers should report incorporation method when publishing results on CRF in container-plant production. Container-plant producers should ensure that their mechanical-incorporation equipment does not cause unintended damage to their CRF of choice.

LITERATURE CITED

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