Michigan Department of Agriculture
Contact: Mike DiBernardo

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Final Performance Report
February 1, 2011

Project Title
Sustainable nutrient and water management for container tree production

Project Summary
Landscape tree nurseries in Michigan are faced with several challenges. These include adapting to a shift in the industry from traditional field production to container production, optimizing nutrition and water management to maximize growth, and meeting rising consumer demands for sustainably- or organically-produced landscape materials. For the past four years we have conducted research trials on improving nutrient and water management of landscape conifers and shade trees in Pot-in-Pot container production. (Klooster et al., 2010; Taylor et al., 2009). The overall goals of the current phase of our Pot-in-Pot production research are to expand the capabilities of the system and evaluate components of production systems for container-grown conifers and shade trees that will enable growers to market plants as certified Organic or certified Naturally-grown.

Project Approach
Our project partner is: Dr. Bert Cregg, Michigan State University, Department of Horticulture and Department of Forestry, East Lansing, MI 48824-1325, Telephone (517) 355-5191 ext. 1335, Email: cregg@msu.edu

The specific objectives of this project are to:
1. Increase the research capacity of the MSU Pot-in-Pot research nursery by adding an automated drainage measuring system; making it a state-of-art facility for water and nutrient management research on container-grown landscape trees.
2. Compare the growth and quality of landscape shade trees and conifers grown with conventional fertilizers and organic-approved fertilizers.
3. Develop whole-crop water and nutrient budgets for shade tree and conifer crops grown with conventional and organic-certified fertilizers.

The results of the project will provide baseline information on the potential to produce container-grown trees under organic management as well as comparative data on the potential environmental impacts of conventional and organic production. Moreover, enhancements to the MSU Pot-in-pot nursery facility will provide the infrastructure for continued investigations on sustainability of container tree production.

Goals and Outcomes Achieved
Objective 1. Installation of automated leachate measurement system.

In the spring of 2010 we installed a new two-year nursery trial at the MSU Pot-in-Pot research nursery at the Michigan State University Horticulture Teaching and Research Center to compare growth, physiology, and nutrient leaching of common nursery trees under conventional and organic fertilization. The 25-gallon container section and the 7-

gallon container section of the nursery were retro-fit with a leachate collection system under the containers (Photo 1). The leachate collection system was designed to collect leachate from 8 containers from each of 8 rows in each production area (Photo 2). Container leachate from each row was collected and total run-off was measured by a series of tipping bucket rain gauges and an automated data logger (Zhu et al. 2005). The system was completed in early July 2010 (Photos 3 and 4). Trees in each section of the nursery were irrigated daily at 09:00 via spray stakes (Netafim, Inc) operated by an automated timer. Irrigation and rainfall in excess of daily plant water use leached through the containers and collected by tipping buckets and recorded by the datalogger (Figure 1.) After an initial assessment and trouble-shooting period, irrigation rates were adjusted for each container section in early August in order to achieve a target leaching fraction of 10-20% of irrigation applied. Subsequent to this adjustment, major peaks in leaching through the system were associated with rainfall events (Figure 2). The system operated essentially trouble-free following installation until irrigation ceased at the end of October. The only minor difficulty encountered was one plugged drain-line in one plot of the 25 gallon containers, which was easily remedied.

<u>Objective 2. Comparison of growth and quality of container-grown trees grown under conventional and organic nutrition management.</u>

Following installation of the leachate collection system we planted 200 35 mm caliper London planetree (*Plantanus* x *acerifolia* 'Bloodgood') liners in 25 gallon containers and 100 conifers (50 Colorado blue spruce (*Picea pungens*) and 50 Fraser fir (*Abies fraseri*) in 7 gallon containers. All trees were planted in a standard container substrate of 80% pine bark and 20% peat moss (v:v) (Renewed Earth, Inc. Kalamazoo, MI). Four rows of trees in each nursery section were assign at random to receive either a conventional controlled-release fertilizer (Osmocote Plus 15-9-12, 5-6 month release, Scotts, Inc., Marysville, OH) or an OMRI-certified organic fertilizer (NatureSafe 10-2-8 and NatureSafe 5-6-6, Griffin Industries, Cold Spring, KY). The organic fertilizers were blended to provide approximately the same ratio of N-P-K as the conventional source (Table 1). Fertilizers were applied at a rate of 30 grams N per container for trees in the 25 gallon containers and 12 grams of N per container for trees in the 7 gallon containers. Application of the organic fertilizer was split into two applications, once in early July and once in mid-August. We measured height and trunk caliper at the start of the study and at the end of the growing season. Foliar samples were collected for nutrient analysis in September (planetrees) and November (conifers). Net photosynthetic gas exchange of the conifers was measured on three dates (Aug. 8, Aug. 31 and Oct. 7) using a portable photosynthesis system (Li-6400, Li-cor, Inc.) equipped with a 0.25-liter cylindrical conifer chamber. Gas exchange measurements were collected on all conifers in the study between 10:00 and 16:00 on clear days (photosynthetically active radiation (PAR) >1500 mol m^{-2} s^{-1}). Gas exchange of leaves of 'Bloodgood' planetrees was measured on Aug.2 and Sept. 3 using a portable photosynthesis system (LI-6400), equipped with a 6 cm^2 broad-leaved chamber with a red-blue LED light source set to 1500 mol $m^{-2}s^{-1}$ of PAR. All measurements were collected between 10:00 and 16:00.

Results from the first year of the trial indicate that fertilizer source (conventional versus organic) affected ($p<0.05$) stem caliper growth of conifers but not planetrees. Conifers fertilized with conventional controlled-release fertilizer grew an average of 25% larger in caliper than trees fertilized with the same amount of nitrogen in the organic form. Planetrees grew an average of 4.8 mm in caliper with conventional fertilizer and grew an average of 4.5 mm with the organic product. Foliar nutrient levels in planetree leaves did not differ ($p>0.05$) between conventional and organic fertilizer treatments for most elements (Table 2). Conventional fertilization increased ($p<0.05$) foliar manganese compared to trees receiving the organic fertilizer. (Table 2). Foliar manganese levels of trees from both treatments were above sufficiency standards. Fertilizer source, date, and species affected net photosynthesis of conifers. Across the season, conventional fertilization increase net photosynthesis of conifers relative to the organic fertilizer (Fig. 3). Fertilizer source did not affect net photosynthesis of 'Bloodgood' planetrees (Table 3). However, water use efficiency (ratio of net photosynthesis to stomatal conductance) was higher for trees fertilized with conventional fertilizer due to reduced stomatal conductance relative to trees fertilized with organic fertilizer.

<u>Objective 3. Develop whole-crop water and nutrient budgets for shade tree and conifer crops grown with conventional and organic-certified fertilizers</u>
Nutrient and water budgets are being developed from whole-tree biomass samples collected at the end of the 2010 growing season, leachate run-off data, and irrigation and fertilization records. We are also awaiting results of residual analysis by Scotts, Inc. of fertilizer prills collected at the end of the 2010 growing season. Periodic subsamples of leachate collected from the container leachate system indicated that nitrate levels were consistently higher for conifer trees in 7-gallon containers fertilized with conventional fertilizer than for trees receiving the organic fertilizer. Nitrate concentration of leachate from the 25-gallon containers did not show a consistent difference between conventional and organic fertilizer, and overall concentrations were comparable between the two treatments.

Beneficiaries

Between 2001 and 2005 the number of USDA Certified organic nurseries and greenhouses increased by over 15-fold, A desire to be environmentally conscious is a substantial market driver influencing purchase organic products. Standard container nursery production systems are resource-intensive and rely heavily on inorganic fertilizers, herbicide-based weed control, and use of inorganic pesticides. In order to qualify as USDA Certified Organically grown, producers must follow USDA Organic Certification guidelines. (USDA) These require that no inorganic pesticides or fertilizers be applied to production areas for three years and that all fertilizers and pesticides used in the production system are approved by the Organic Materials Resource Institute (OMRI).
Meeting crop needs without the use of inorganic fertilizers will be one of the largest challenges for organic nursery producers (Chong, 2005; Chong et al., 2008; Manas et al.

2009). The results of this study will provide Michigan growers with initial guidelines for organic nutrient additions that will result in acceptable crop growth.

Lessons Learned

Through the first year of the study, growth and foliar nutrition of 'Bloodgood' planetrees was similar with either conventional or organic fertilization. This suggests that growers may use either fertilizer source. Caliper growth of conifers was greater with conventional controlled release fertilizer rather than with organic fertilization. In the conifer portion of the study, conventional fertilization resulted in greater fertility (higher nitrate levels), which resulted in higher rates of photosynthesis and growth. We are currently processing biomass samples and fertilizer prills in order to complete water and nutrient budgets.

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Additional Information

Publications and Presentations

Cregg, B.M.. A. Taylor, W. Klooster, R.T. Fernandez and P. Nzokou. 2010. Growth and physiology of living Christmas tree in container production. IN: Hart, J. Landgren, C. and Chastagner, G. (Eds.) Proceedings of the 9th International Christmas Tree Research and Extension Conference, Corvallis, OR and Puyallup, WA. p. 28-33.

Nzokou, P. and B.M. Cregg. 2010. The effect of watering and nitrogen fertilization on growth, nutrient use, and leaching in containerized Fraser fir (*Abies fraseri*). Proceedings of the 9th International Christmas Tree Research and Extension Conference, Corvallis, OR and Puyallup, WA. p. 37-44.

Cregg, B.M. 2010. Pot-in-Pot production for living Christmas trees. National Christmas Tree Association. Winston-Salem, NC. Aug. 12, 2010.

Cregg, B.M. 2010. Container production for conifers. Michigan Christmas tree Association Summer meeting. Paw Paw, MI, July 24, 2010.

Cregg, B.M. 2010. Pot-in-Pot production for living Christmas trees. Wisconsin Christmas Tree Producers Association, Waukesha, WI, Jan. 22, 2010.

References

Klooster, W.S., B.M. Cregg, R.T. Fernandez, and P. Nzokou. 2010. Growth and photosynthetic response of Pot-in-pot-grown conifers to substrate and controlled-release fertilizer. *HortScience 45:36-42*.

Taylor, A., B. Cregg, R.T. Fernandez, and P. Nzokou. 2009. Growth and physiology of living Christmas trees under cyclic irrigation. 2009 ASH National Conference, St. Louis, MO.

Zhu, H., Krause, C.R., Zondag, R.H., Brazee, R.D., Derksen, R.C., Reding, M.E., Fausey, N.R. 2005. A new system to monitor water and nutrient use efficiency in pot-in-pot nursery production system. Journal of Environmental Horticulture. 23(1):47-53.

Table 1. Fertilizer program for 'Bloodgood' planetrees (25 gallon containers) and conifers (7 gallon containers) in comparison trial of conventional and organic fertilization

25 gallon containers				Elemental totals (g/container)		
	app 1 (July)			N	P	K
Osmocote 15-9-12	200 grams			30	18	24
	App 1 (July)	App 2 (Aug)	total			
Nature Safe 10-2-8	125 grams	75 grams	200 grams	20	4	16
Nature Safe 5-6-6	125 grams	75 grams	200 grams	10	12	12
Total				30	16	28

7 gallon containers				Elemental totals (g/container)		
	App 1 (July)			N	P	K
Osmocote 15-9-12	80 grams			12	7.2	9.6
	App 1 (July)	App 2 (Aug)	total			
Nature Safe 10-2-8	50 grams	30 grams	80 grams	8	1.6	6.4
Nature Safe 5-6-6	50 grams	30 grams	80 grams	4	4.8	4.8
Total				12	6.4	11.2

Table 2. Mean (s.e.) foliar nutrient concentration of ‘Bloodgood’ planetrees grown with organic or conventional fertilization

	Fertilizer source	
Element	Organic	Conventional
N (%)	1.91(0.09)	2.14(0.10)
P (%)	0.13(0.01)	0.15(0.01)
K (%)	0.64(0.05)	0.68(0.08)
Ca (%)	1.01(0.03)	1.03(0.03)
Mn (ppm)	239.5(11.3)	291.5(15.9)*
Fe (ppm)	73.0 (3.8)	80.2(5.3)
B (ppm)	27.4(1.4)	31.8(1.3)
Mb (ppm)	10.8 (3.1)	13.1 (2.1)

NOTE: * indicates significant ($P<0.05$) difference between mean of Organic and Conventional fertilizer

Table 3. Mean (s.e) net photosynthesis, stomatal conductance, and water use efficiency of 'Bloodgood' planetrees grown with organic or conventional fertilization

Fertilizer source	Net photosynthesis (μmol m^{-2} s^{-1})	Stomatal conductance (mmol m^{-2} s^{-1})	Water Use Efficiency (mmol $mmol^{-1}$)
Organic	10.47[a] (0.20)	0.23[a] (0.004)	48.82[a] (0.66)
Conventional	10.82[a] (0.20)	0.19[b] (0.005)	59.22[b] (1.05)

NOTE: Means in a column followed by the same letter are not different at P = 0.05.

Photo 1. Research Technician Aaron Warsaw installs trenches for leachate collection system for MSU Pot-in-Pot research nursery

Photo 2. 7-gallon socket containers fitted with funnels and collection line about to be re-installed in MSU Pot-in-Pot research nursery

Photo 3. ‘Bloodgood’ plane trees in 25-gallon containers in MSU Pot-in-Pot research nursery

Photo 4. Colorado blue spruce and Fraser fir trees in 7-gallon containers in MSU Pot-in-Pot research nursery. Bottom left: Covers for tipping bucket collectors.

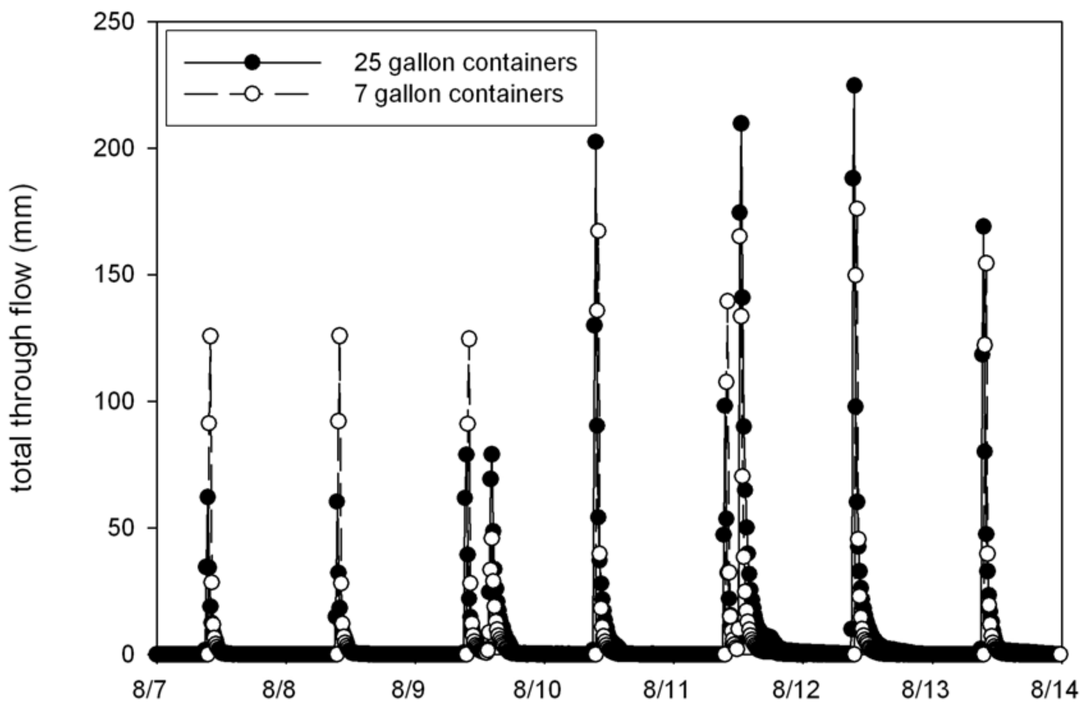

Figure 1. Example of continuous (15-minute) recording of total through-flow of leachate by tipping bucket gauges. Peaks represent irrigation events (e.g., 8/7) or irrigation + rainfall (e.g., 8/11).

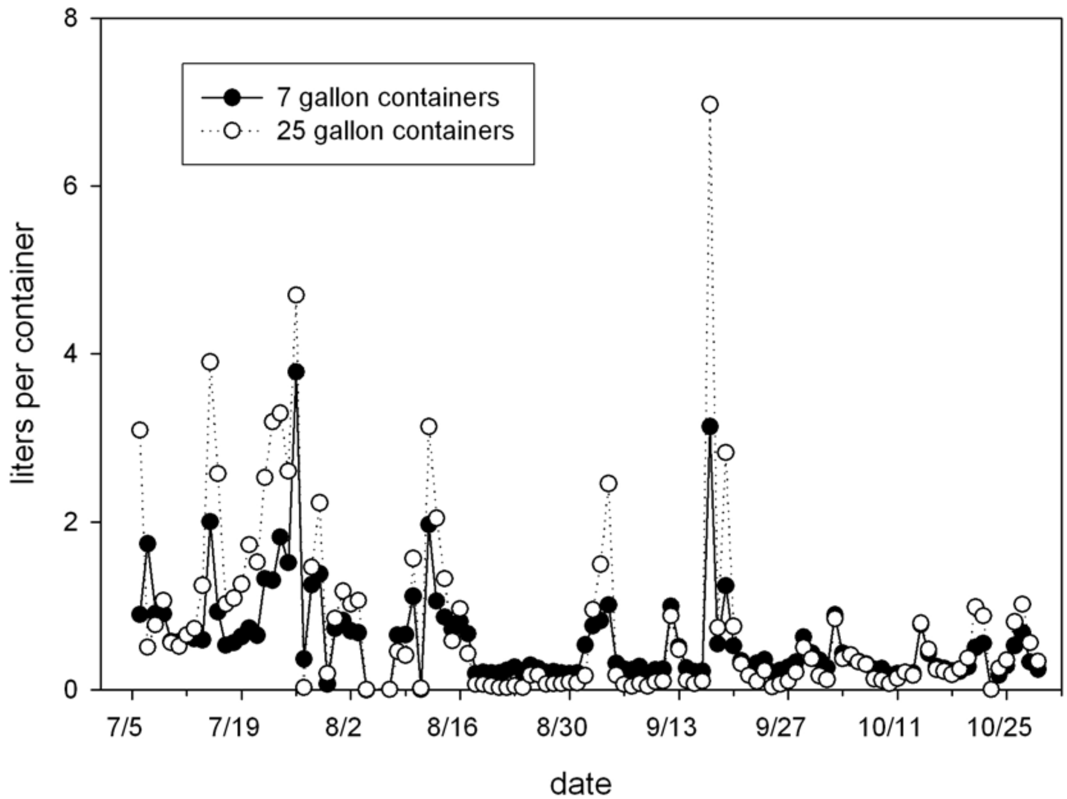

Figure 2. Daily leaching amount (liters per container) of ‘Bloodgood’ planetrees (25-gallon containers) and Colorado blue spruce and Fraser fir (7-gallon containers).

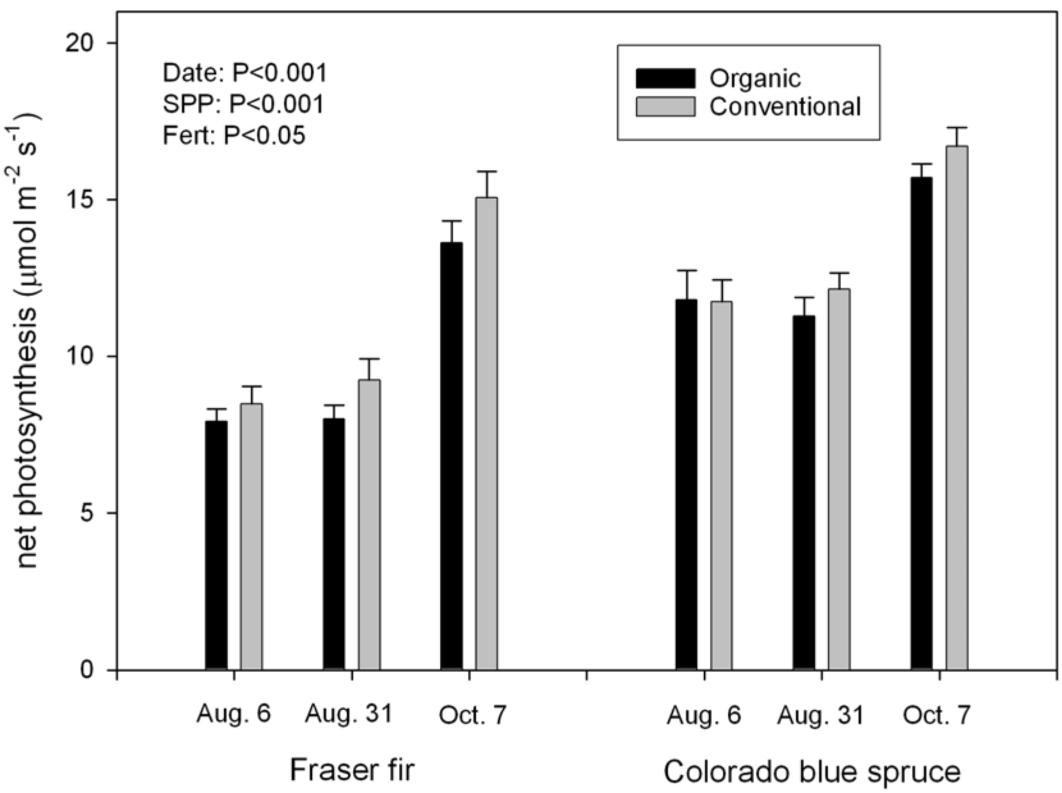

Figure 3. Net photosynthesis of Fraser fir and Colorado blue spruce trees grown in 7-gallon containers and fertilized with conventional and organic fertilizer,

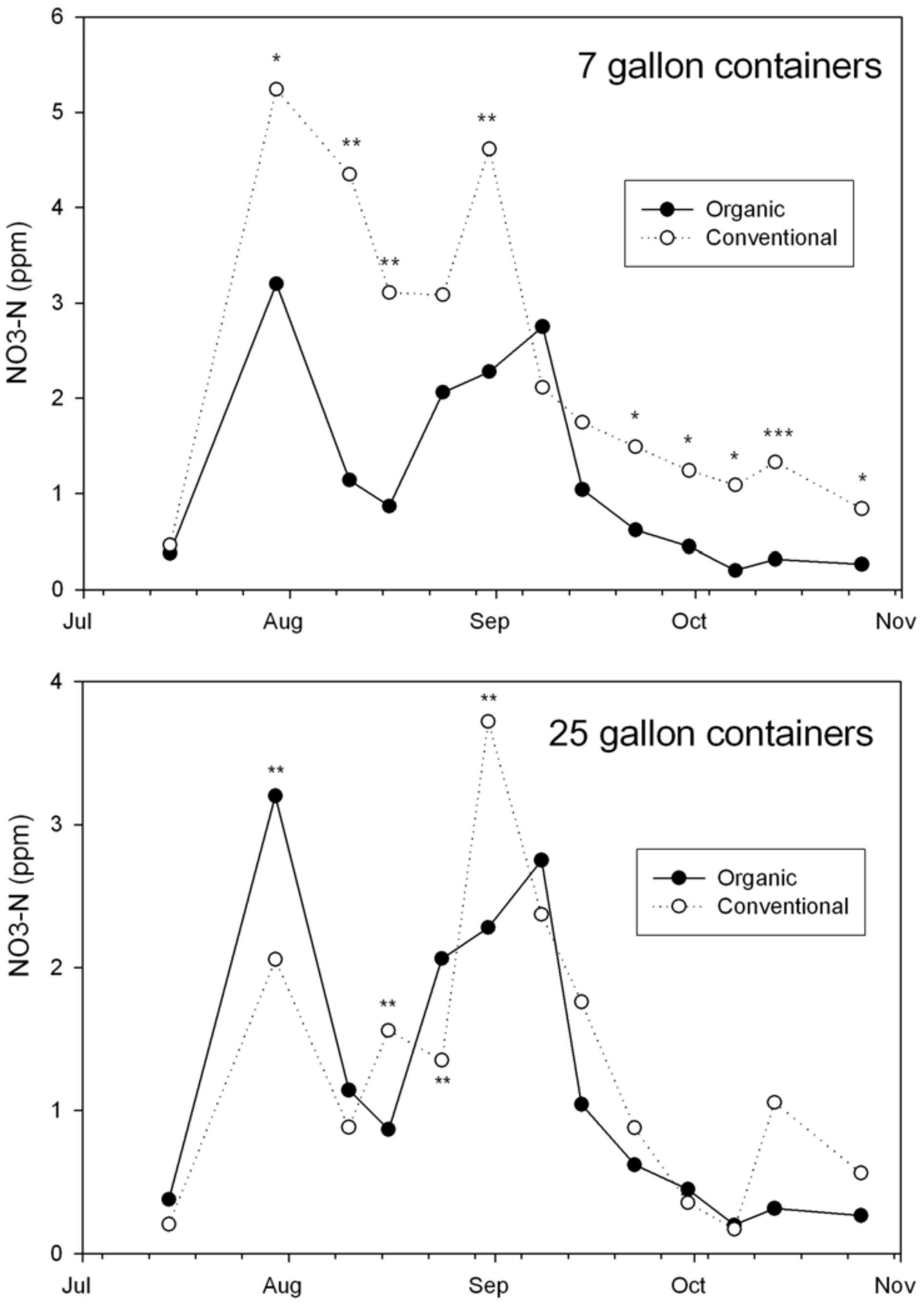

Figure 4. Mean nitrate concentration of leach samples collected from 7-gallon and 25-gallon production areas of MSU Pot-in-Pot nursery.