Fertilization Guide for Container-Grown Nursery Crops

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Introduction

Currently, the vast majority of North America's container-grown nursery crops are produced using soilless growing substrates and fertilized with controlled-release fertilizers (CRF). The most commonly used CRF include Polyon, Nutricote, Osmocote, and Acer. Each brand has different products, or fertilizers with different nutrient component ratios (e.g., N:P:K), with applications aimed towards different crops and regional environmental situations (e.g., water quality). Different growers, and even the same grower when producing different crops, often vary the fertilizer frequencies, rates, and application methods (e.g., incorporation, top-dressing, dibble, or combinations).

Under certain growing conditions for a given crop, growing substrate, fertilizer type, and irrigation practice, there is an optimal fertilizer application rate, method, or method combination. Excess fertilization and irrigation is not only costly, but can also injure plants and cause unnecessary nutrient runoff, resulting in environmental damage. However, insufficient fertilization can cause plant nutrient deficiencies, reduce crop productivity, and eventually reduce the efficiency of other resource inputs during nursery crop production. When optimal fertilizer application rates are used, nursery crops perform at their best, and growers are able to increase their profit margin, and minimize environmental impacts.

Since many different growing substrates, crops, climates, management practices, fertilizer types, etc. are combined at nursery operations throughout North America, it is impossible to do trials to include all the combinations in order to determine the optimal fertilizer rate for every situation. Therefore, in the past several years, we have conducted numerous on-farm trials, with representative, industry-standard cultural practices, using the most common crops, growing substrates, and fertilizer types in order to provide fertilization guides for nursery operations in temperate climate regions such as Ontario, Canada and some states in northern USA.

Based on our research, it is obvious that when fertilizing container-grown nursery crops, we need to take the following principles into consideration.

1. **Different species have different fertilization requirements**

By understanding species-specific responses to fertilization and unique, optimal fertilizer rates for individual nursery crops, growers can divide crops into fertilizer requirement groups (i.e., low, medium, and high fertilization groups) during production. Groups of crops with different fertilizer requirements can be potted with their optimal fertilizer rates at different times, to ensure planting and fertilizer-use efficiency. By applying the recommended fertilizer rate to nursery crops, growers can easily optimize plant growth and minimize excessive nutrient loss from over-fertilization. Based on our observations and discussions with growers, many Ontario nursery operations are currently applying one fertilizer rate for all plant species on the same farm, and some operations are grouping their plants according to water demand, which is a model that can also be applied to fertilization. Growers may like to use these species-specific optimal fertilization rate results, and information from other sources, to determine appropriate nursery crops to group together during production.

2. Fertilizer can be used to accelerate or slow plant growth

Our research showed that applying an appropriate high fertilizer rate is able to shorten production time, compared to lower rates, thereby saving water, space and labour costs. However, fertilization rates should be selected to finish crops based on the anticipated shipping schedule, otherwise over-fertilization may cause excess plant growth, resulting in additional labour costs associated with maintaining and pruning these plants.

3. Increasing fertilizer application rate can increase nutrient loss to the environment

Our results demonstrated that increasing the fertilizer application rate increased N and P loss to the environment. To reduce nutrient loss to the environment, it is a good practice to apply the lowest possible fertilizer rate. However, the rate should provide adequate nutrition for plant growth, since nutrient deficiencies can cause crop failure or prolonged production time, potentially resulting in wasted resources or environmental damage.

4. Timing and methods of fertilization

Determining when and how to apply CRF is critical in container nursery crop production. For example, CRF are manufactured to release nutrients at different rates following application, with the expected nutrient release duration ranging from a few weeks to more than a year. An industry practice of applying a high rate of long-duration CRF in the first production year has been considered a way to avoid topdressing labour costs in the second year; however, our research showed that this may not be a good practice. For example, when western red cedar (*Thuja plicata* 'Whipcord') liners were potted in 1-gal containers, and an 8–9 month CRF fertilizer was incorporated at multiple rates, the highest rate resulted in a high substrate EC early in the growing season, but the EC quickly decreased during the first two months after transplanting (i.e., an EC change of > 8 $mS \cdot cm^{-1}$ to < 1 $mS \cdot cm^{-1}$; Agro, 2014). Therefore, these results suggest applying less fertilizer more frequently to increase fertilizer use efficiency.

To investigate different fertilizer application methods on the growth of container-grown forsythia (*Forsythia* x *intermedia* 'Spring Glory') and nutrient leaching to the environment, Alam et al. (2009) found that a dibble fertilizer placement is superior to both incorporation and topdress for plant growth, under drip irrigation. When application methods were compared, the greatest concentrations of NO_3-N generally leached from containers with incorporated fertilizer, followed by dibbled and topdressed applications. In addition, splitting the CRF application into two application times greatly reduced NO_3-N in leachate.

There are many different CRF products available to growers, differing in nutrient release mechanisms, durations, and patterns, as influenced by climactic conditions. In addition, nursery production management practices, such as irrigation, influence nutrient release from CRF. Recent research has shown that both timing and methods of CRF application are important to maximize nutrient-use efficiency and minimize nutrient loss to the environment.

5. Leaf tissue analysis alone may not be able to identify nutrient deficiencies

Evaluating plant leaf nutrient content by conducting a tissue analysis may help to identify nutrient disorders (e.g., deficiencies) for certain species under certain conditions. However, leaf tissue nutrient sufficiency ranges are currently unknown for the majority of container-grown nursery crops, which limits the ability of growers to clearly determine tissue nutrient deficiencies from tissue nutrient analysis results. In addition, for some species, leaf tissue analysis alone may not be able to identify nutrient deficiencies. For example, in our trials, even when tissue nutrient content values were within the published sufficiency range, poor plant growth and performance were observed at low fertilization rates. Conversely, when nutrient contents were below the sufficiency range, no negative impacts were observed for plant growth or performance. We suspect plant growth influences leaf tissue nutrient content by diluting or concentrating nutrient levels in fast- and slow-growing crops, respectively.

How to use this guide

As discussed above, the optimal fertilizer rate for specific nursery crops depends on many different factors. An optimal rate for a grower who sells the crop in mid-summer, when there is a high demand for landscape plants, may be too high for a grower who sells the crop the following spring. To find out which rate is most appropriate for certain situations, we have presented our results below, grouped by growing region, with summarized results and associated photos. If you need further detailed information, please refer to our other publications, listed below. This guide may be updated when new information comes out.

The research result summaries included in this report illustrate individual trial results, including photos, to help with fertilizer application decisions during container nursery production. The **current and preferred rates** indicate the rate of fertilizer currently used at the nursery, and the **grower-preferred fertilizer rates or ranges** are based on trial results as rated by the participating growers.

Note: *Fertilizer rates in this report are presented on both a nitrogen- and fertilizer-weight basis. If you are using the same fertilizer type as described for the trial, the results can be interpreted based on the weight of the fertilizer per volume of substrate. However, if you are using different fertilizer types, the results can be interpreted based on the nitrogen content of the fertilizer. Since different fertilizer types may have different nutrient compositions, release rates, and longevities, different plant performance results may be produced than those shown in this report.*

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Our other publications for reference

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Research Result Summary: Southwestern Ontario Region

Table 1. Summary of optimal fertilizer rates and/or ranges per nursery crop grown in the Southwestern Ontario region.

Location: Southwestern Ontario Region			
Nursery crop	**Common name**	**Container size**	**Optimal fertilizer rate/range kg N·m^{-3}**
Cornus sericea 'Cardinal'	Cardinal red twig dogwood	1 gal	0.65-2.1
Hibiscus syriacus 'Ardens'	Ardens rose of Sharon	1 gal	0.35-2.5
Hydrangea paniculata 'Grandiflora'	Pee Gee hydrangea	1 gal	0.80-1.7
Salix purpurea 'Nana'	Dwarf purple osier willow	1 gal	0.65-2.5
Spiraea japonica 'Magic Carpet'	Magic Carpet spirea	1 gal	0.65-1.25
Vaccinium corymbosum 'Pink Lemonade'	Pink Lemonade blueberry	1 gal	See results below
Weigela florida 'Alexandra'	Wine and Roses weigela	1 gal	0.65-2.5
Cornus stolonifera 'Flaviramea'	Yellow-twig dogwood	2 gal	1.19-1.49
Euonymus alatus 'Compactus'	Dwarf winged euonymus	2 gal	< 0.60
Hydrangea macrophylla 'Bigleaf'	Bigleaf hydrangea	2 gal	0.75
Hydrangea paniculata 'Grandiflora'	Pee Gee hydrangea	2 gal	1.49
Physocarpus opulifolius 'Nugget'	Nugget ninebark	2 gal	1.19-1.49
Spiraea japonica 'Magic Carpet'	Magic Carpet spirea	2 gal	1.49
Spirea x bumalda 'Goldmound'	Goldmound spirea	2 gal	0.75-1.05
Weigela florida 'Alexandra'	Wine and Roses weigela	2 gal	1.19
Rhododendron 'P.J.M. Elite'	P.J.M. Elite rhododendron	3 gal	See results below
Vaccinium corymbosum 'Polaris'	Polaris blueberry	3 gal	See results below

Southwestern Ontario Region Nursery

Fertilizer: Polyon 16-06-12, 5-6 month incorporated.

Growing Substrate: Gro-Bark Nursery Regular Mix

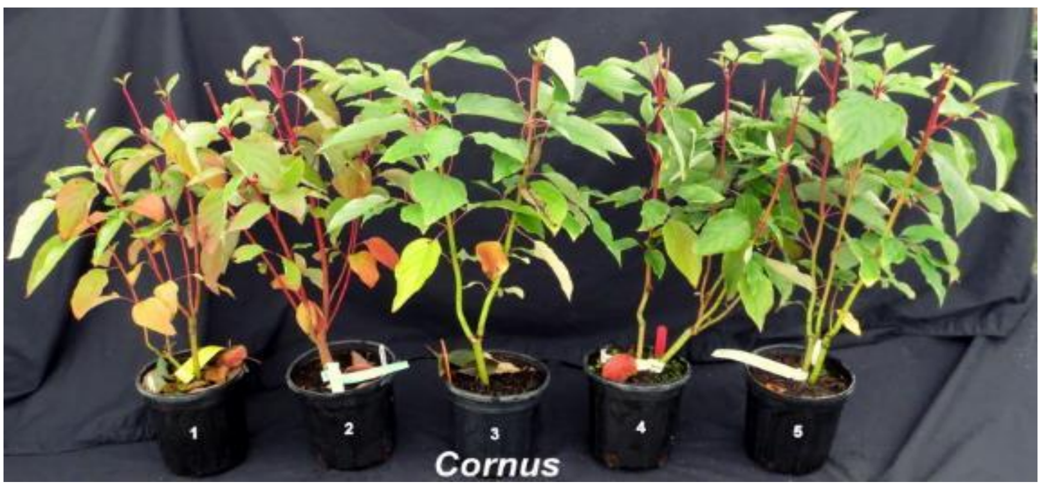
Trial Dates:
1-gal containers (2012 trial: July 3rd – October 5th)
1-gal containers (2013 trial: June 3rd – August 28th)
2-gal containers (2013 trial: June 5th – September 6th)

The following are the growth performance results:

1 gal trial (2012)

Fertilizer rates incorporated:

Treatment :	1	2	3	4	5	Unit
	0.83	1.24	1.66	2.10	2.50	kg N·m^{-3}
	1.40	2.09	2.80	3.54	4.21	lb N·yd^{-3}
	8.74	13.06	17.49	22.12	26.34	lb fertilizer·yd^{-3}

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Weigela


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Hibiscus


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Hydrangea


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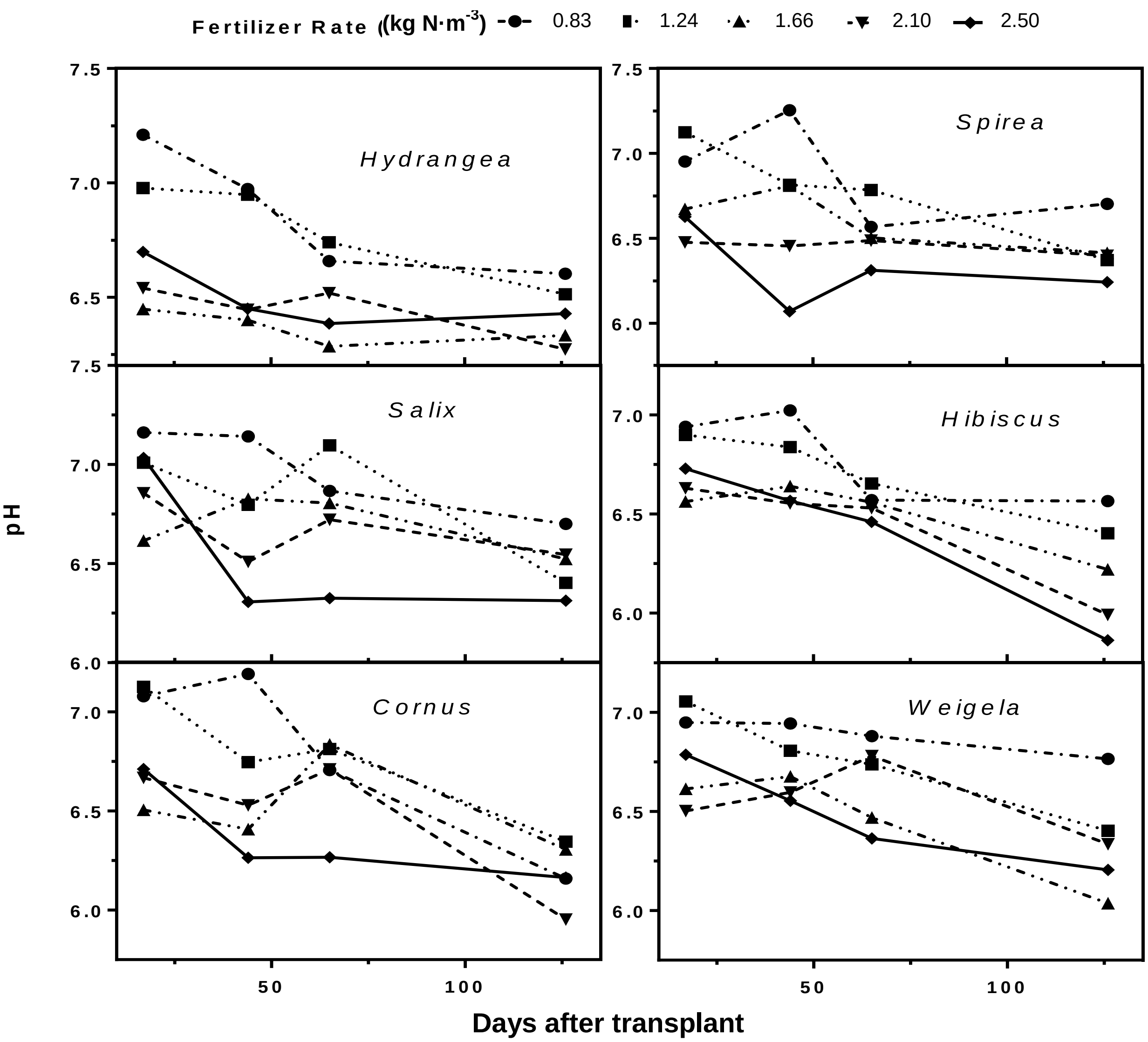
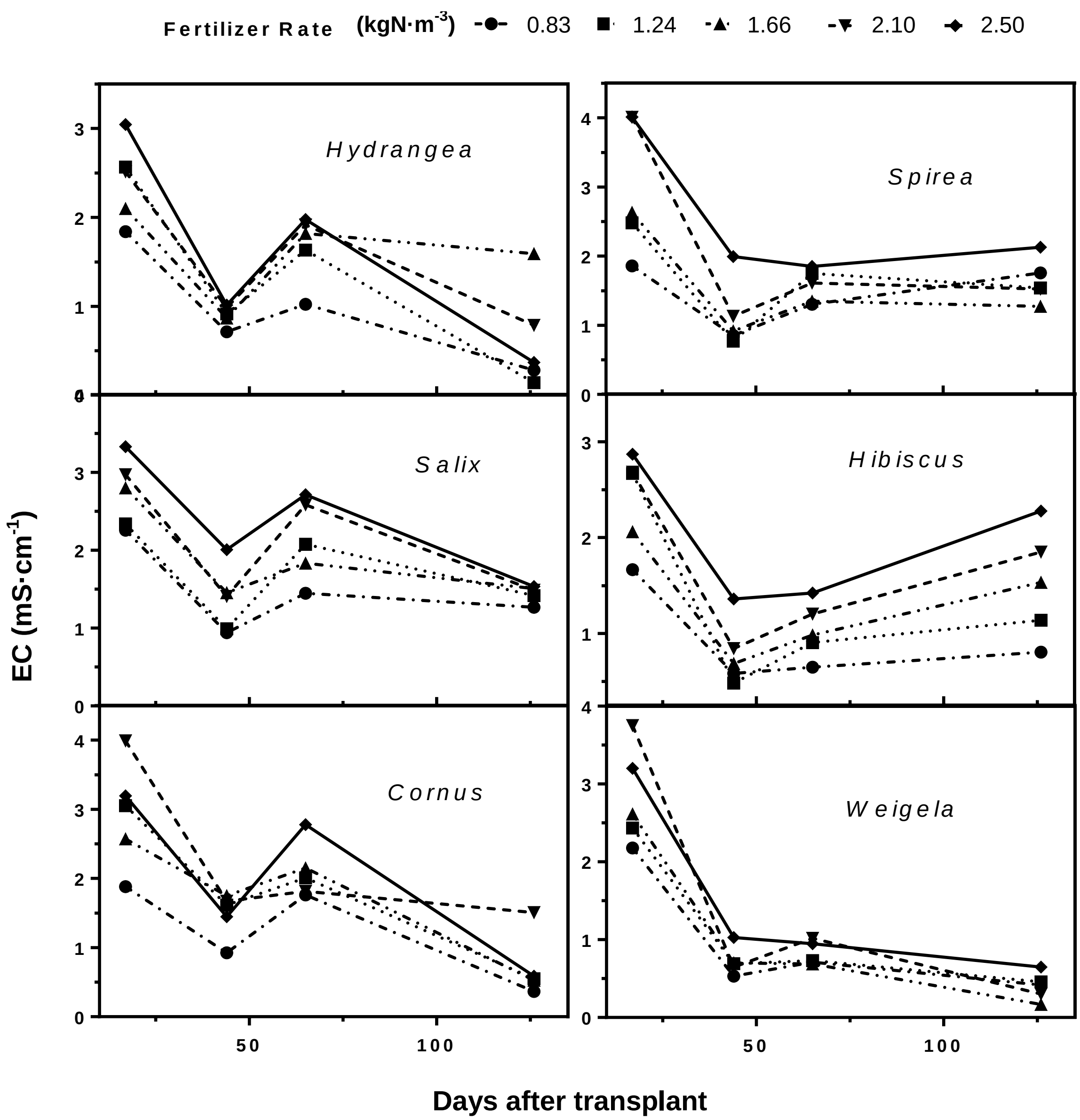
Salix

Substrate pH over time (1 gal 2012)



Substrate EC over time (1 gal 2012)

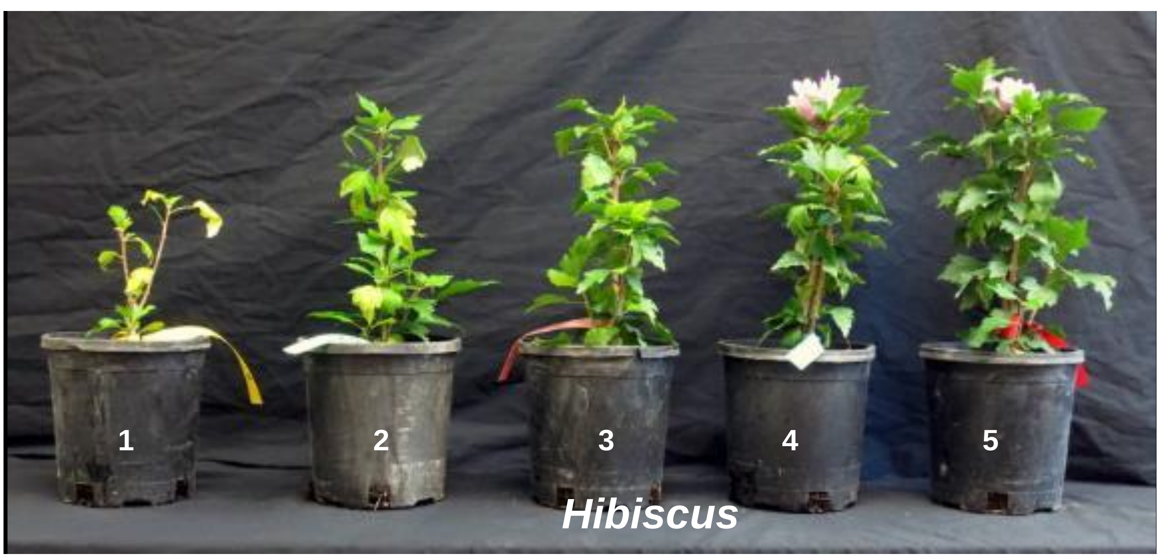


Southwestern Ontario Region Nursery

1 gal trial (2013)

Fertilizer rates incorporated:

Treatment :	1	2	3	4	5	Unit
	0.05	0.35	0.65	0.95	1.25	kg N·m^{-3}
	0.08	0.59	1.10	1.60	2.11	lb N·yd^{-3}
	0.53	3.69	6.85	10.01	13.17	lb fertilizer·yd^{-3}

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Hydrangea


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Spirea


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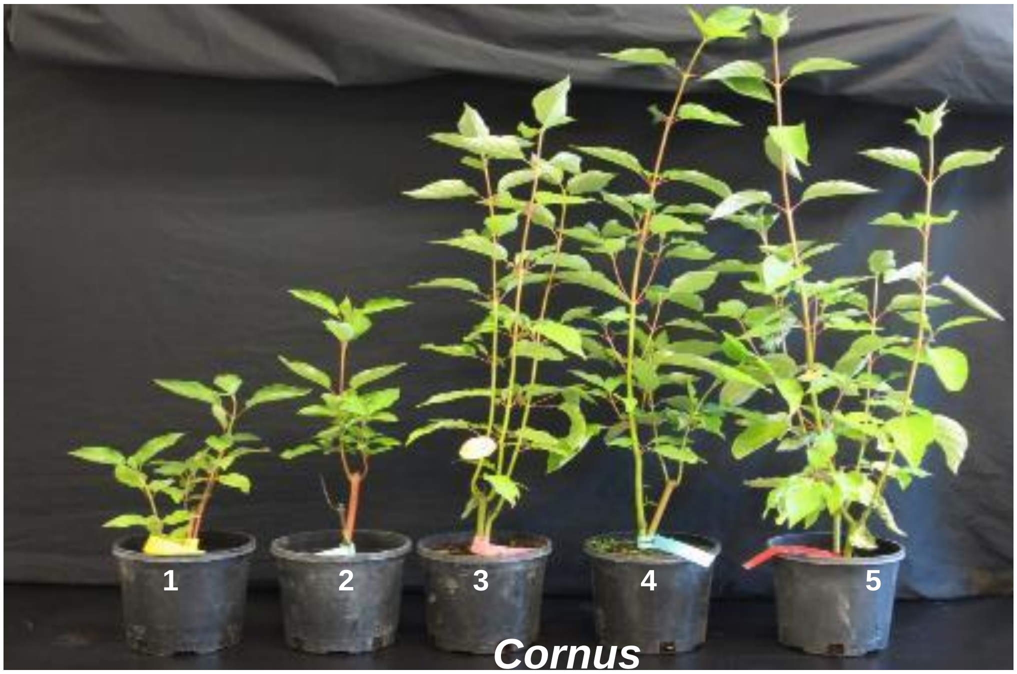
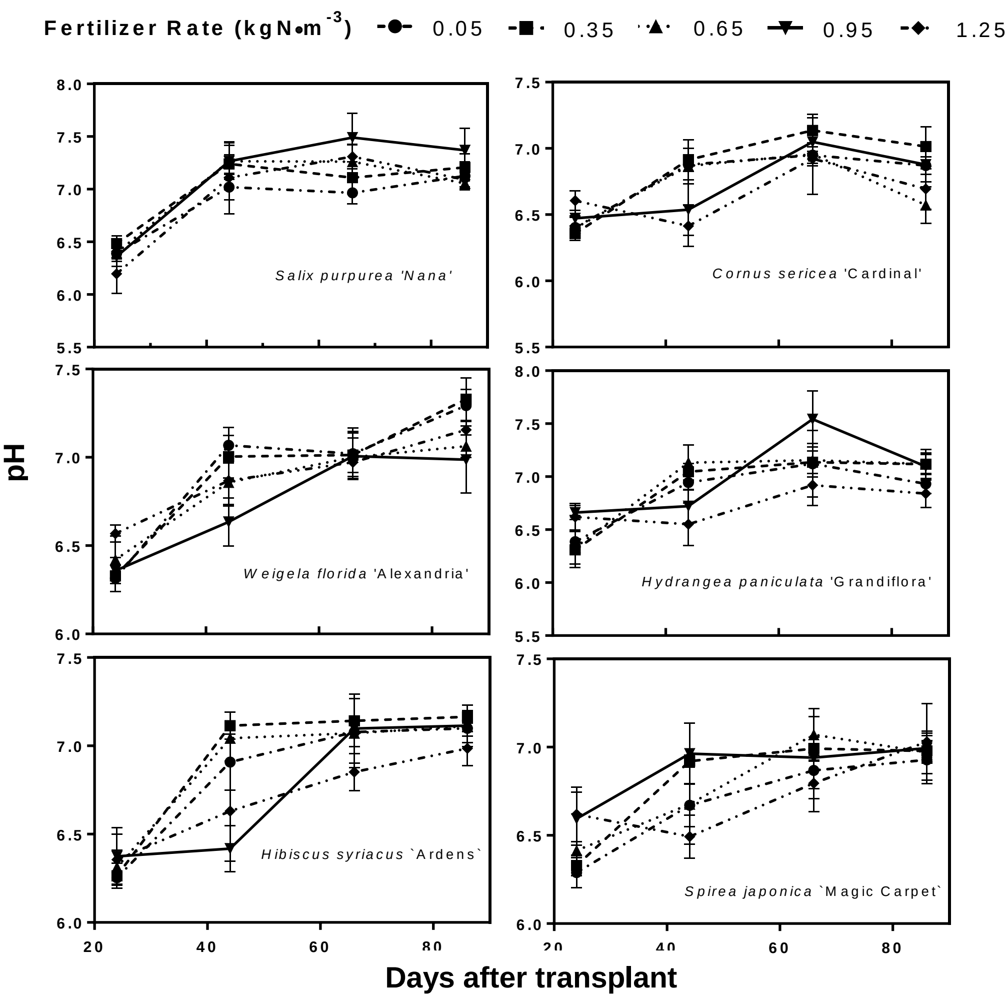
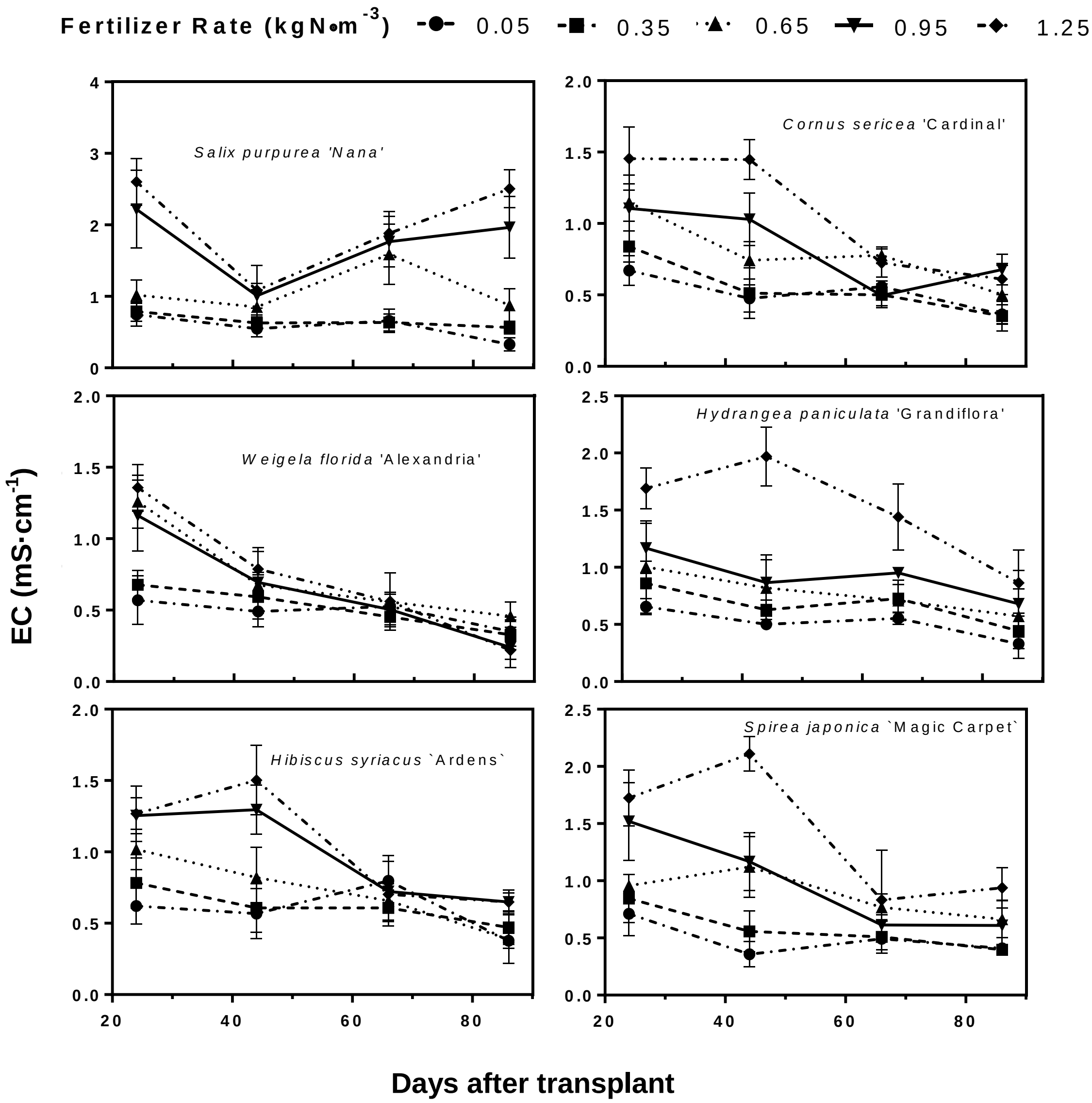
Weigela



Substrate pH over time (1 gal 2013)



Substrate EC over time (1 gal 2013)

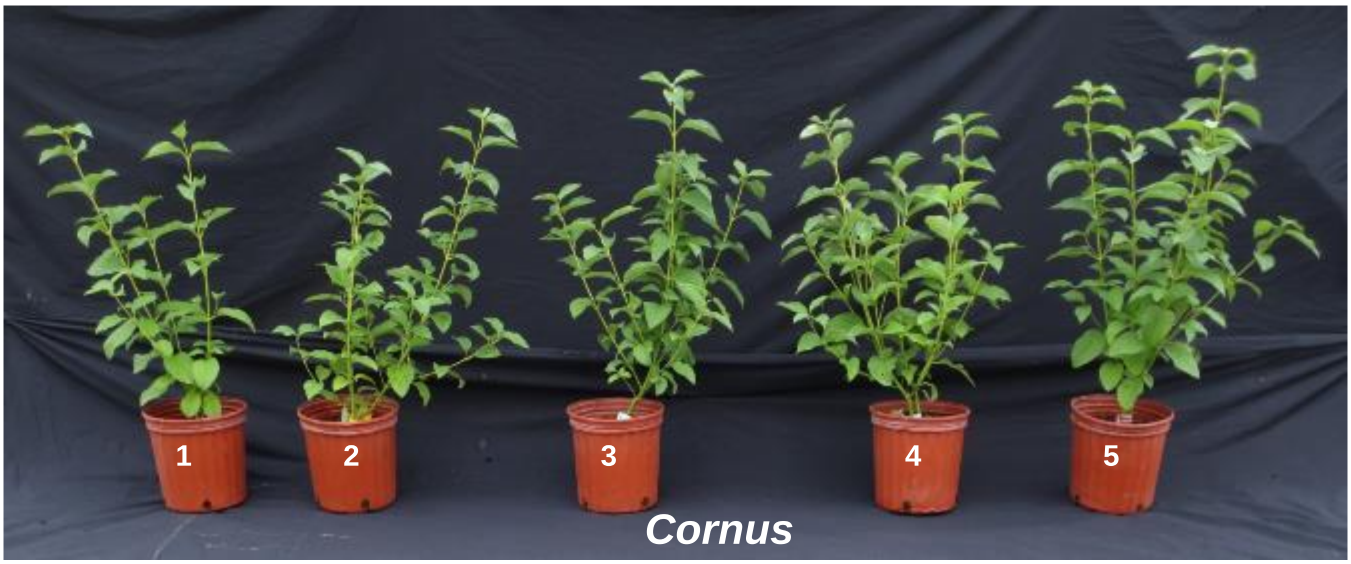


Southwestern Ontario Region Nursery

2 gal trial (2013)

Fertilizer rates incorporated:

Treatment :	1	2	3	4	5	Unit
	0.60	0.89	1.19	1.49	1.79	kg N·m^{-3}
	1.01	1.51	2.00	2.51	3.01	lb N·yd^{-3}
	6.29	9.41	12.53	15.70	18.82	lb fertilizer·yd^{-3}

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Hydrangea


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Physocarpus


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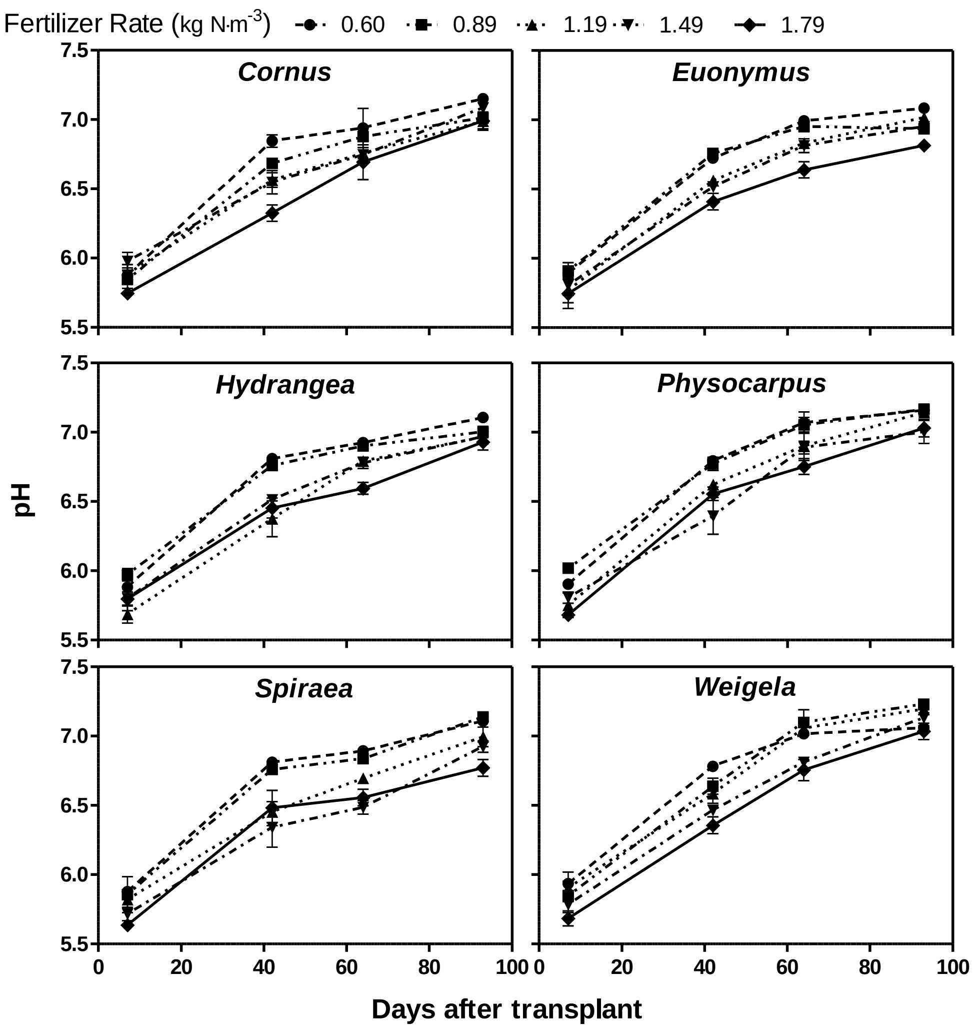
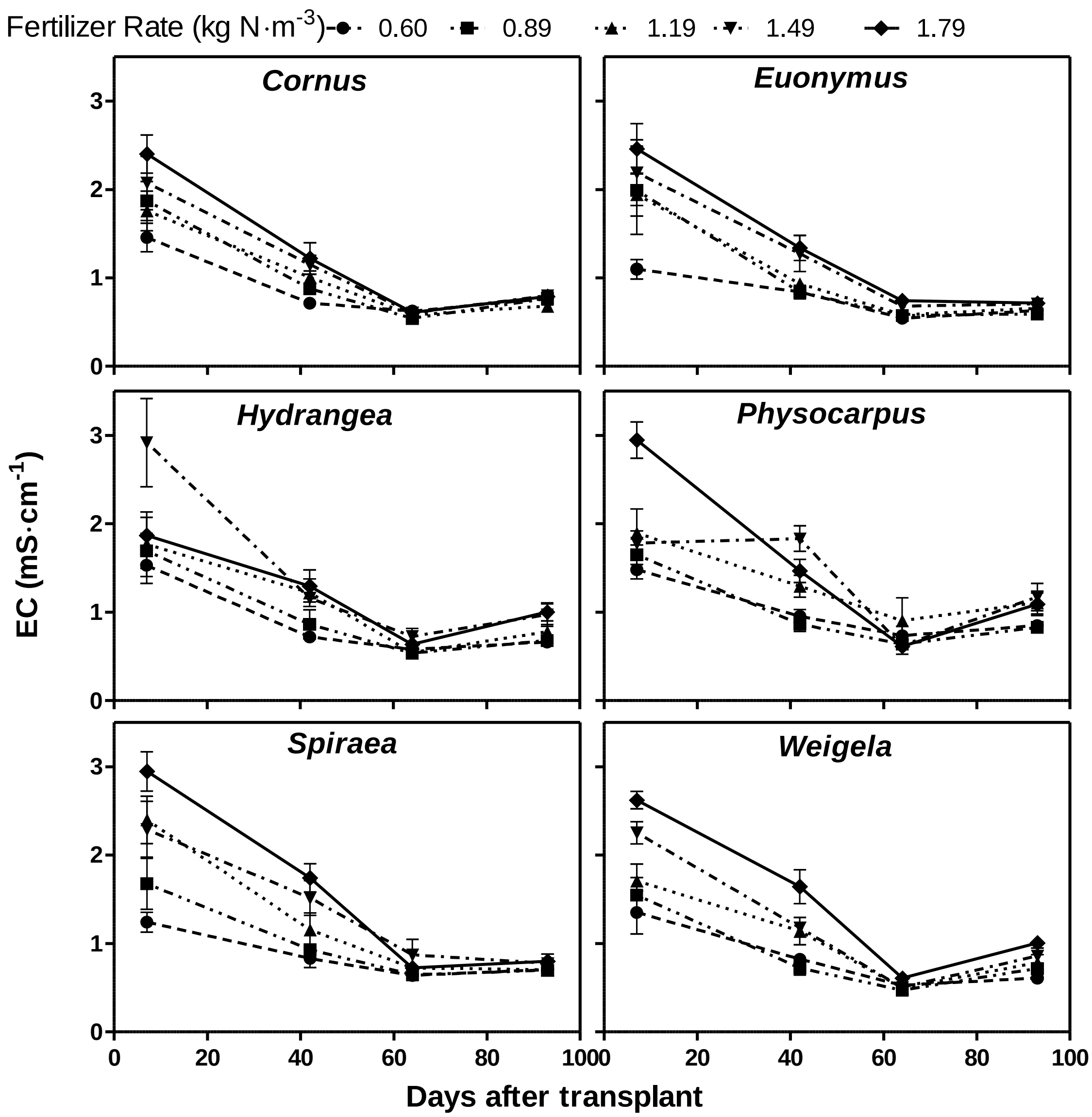
Spirea

Substrate pH over time (2 gal 2013)



Substrate EC over time (2 gal 2013)



Southwestern Ontario Region: Research at the University of Guelph

Fertilizer: Polyon 19-4-10, 8-9 month

Growing Substrate: Composted pine bark, aged bark blend, softwood fines, compost

Trial Dates: May – October, 2016

- **2-gal containers**

Fertilizer rates incorporated:

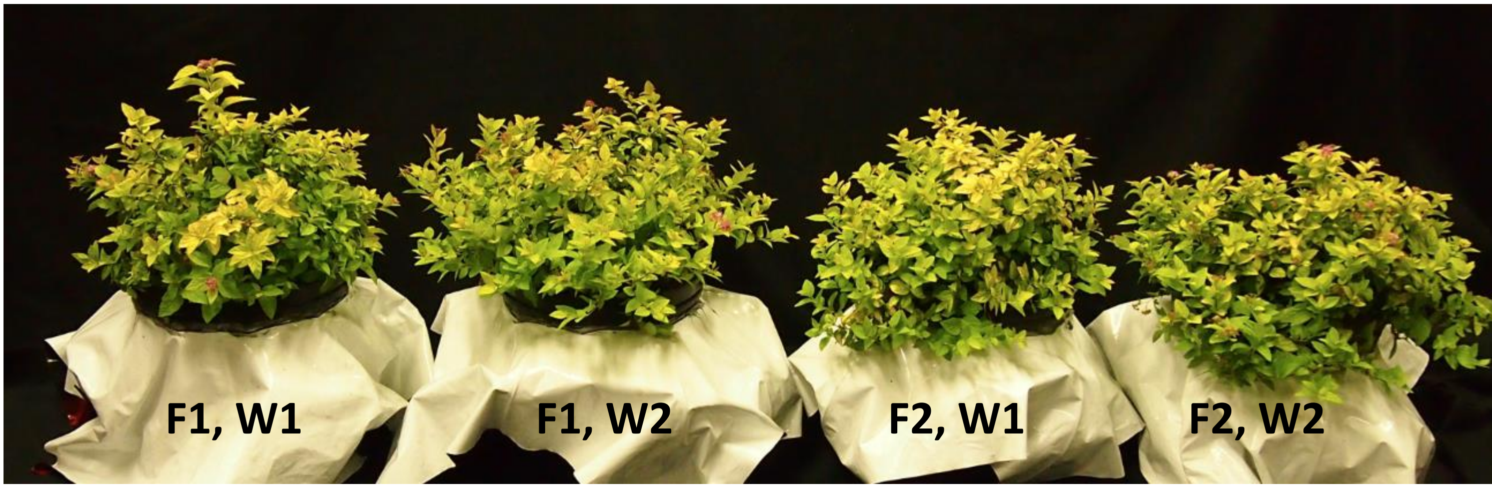
Treatment :	F1	F2	F3	Unit
	0.75	1.05	1.35	kg N·m^{-3}
	1.27	1.78	2.29	lb N·yd^{-3}
	6.68	9.37	12.05	lb fertilizer·yd^{-3}

Irrigation water volumes applied:

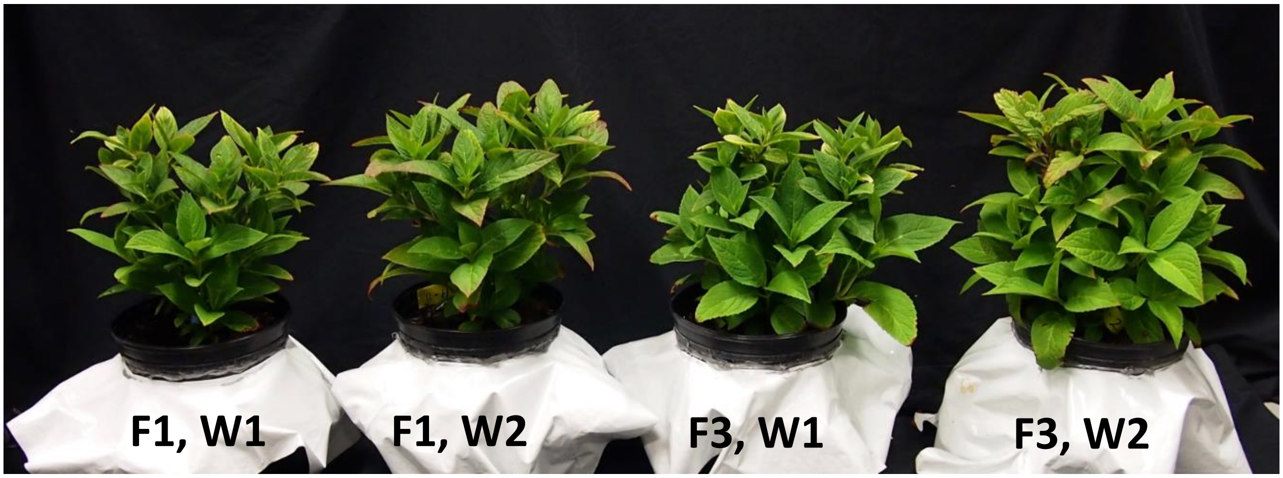
Treatment :	W1	W2	Unit
	0.25	0.35	m^3·m^{-3}

The following are the growth performance results:

***Spiraea x bumalda* 'Goldmound'**



***Hydrangea macrophylla* 'Bigleaf'**


F1, W1
F1, W2
F3, W1
F3, W2

Southwestern Ontario Region: Research at the University of Guelph

The objectives of this study were to determine:

1) Whether acidifying controlled-release fertilizer can be used to manage rootzone pH
2) The optimal fertilizer application rate per nursery crop

Fertilizer: Polyon 16-06-12 Plus Minors, 5-6 month

Growing Substrate: Gro-Bark Nursery Standard Media

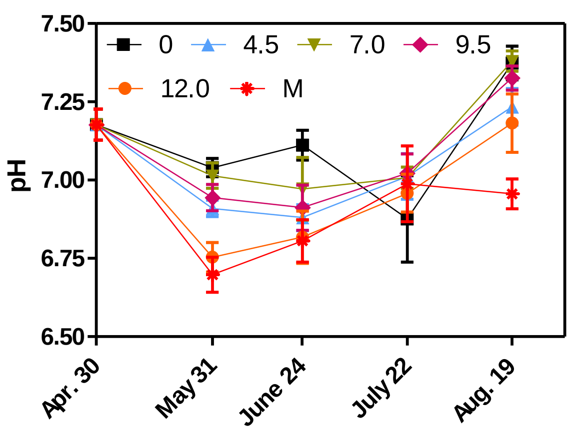
Trial Dates: April – August 2013

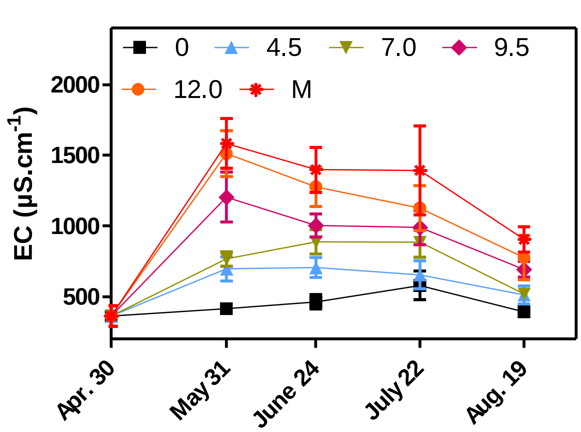
1 gallon *Vaccinium corymbosum* 'Pink Lemonade' Trial

Fertilizer rates top-dressed:

Treatment:	1	2	3	4	5	6	Unit
	0	4.5	7.9	9.5	12.0	M*	g/pot

*M: Multicote 15-7-15, 6 month, 12 g/pot.



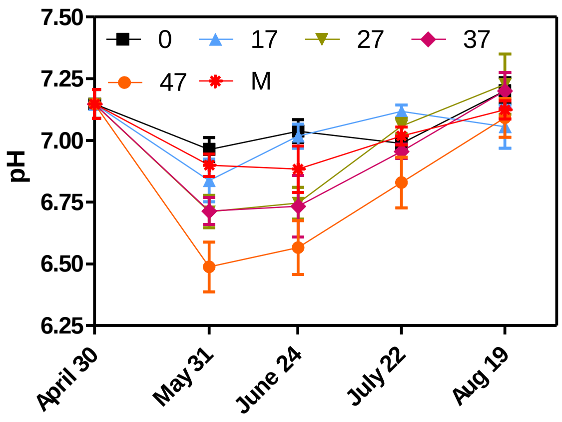


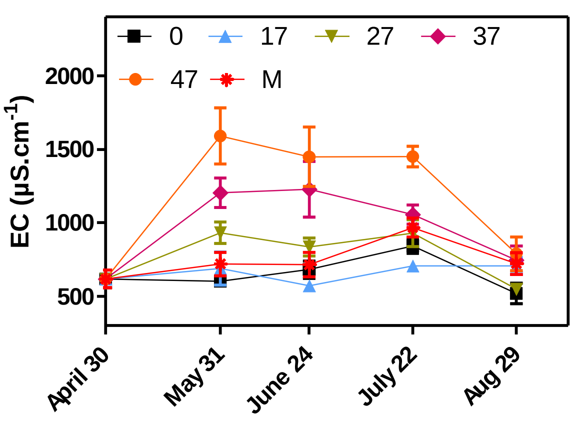
3 gallon *Vaccinium corymbosum* 'Polaris' Trial

Fertilizer rates top-dressed:

Treatment :	1	2	3	4	5	6	Unit
	0	17	27	37	47	M*	g/pot

*M: Multicote 15-7-15, 6 month, 45 g/pot.



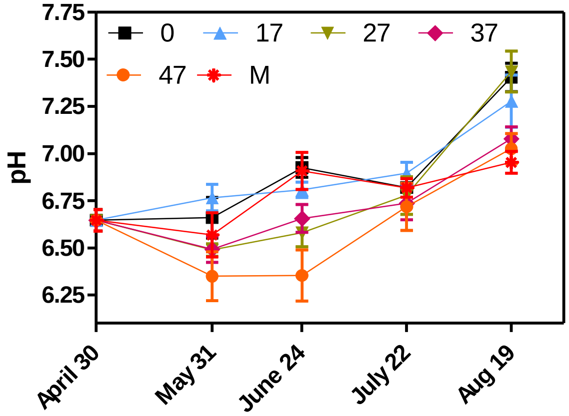


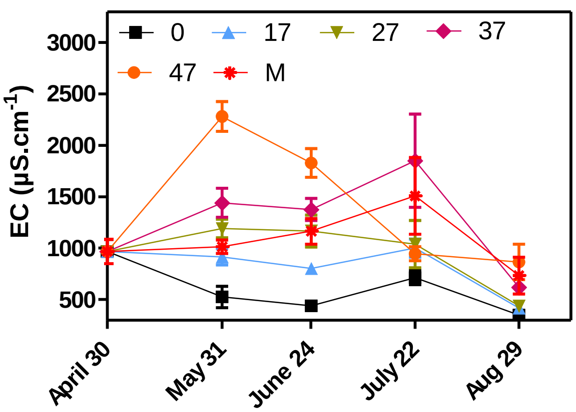
3 gallon *Rhododendron* 'PJM Elite' Trial

Fertilizer rates top-dressed:

Treatment :	1	2	3	4	5	6	Unit
	0	17	27	37	47	M*	g/pot

*M: Multicote 15-7-15, 6 month, 45 g/pot.





Research Result Summary: Halton Region

Table 2. Summary of optimal fertilizer rates and/or ranges per nursery crop grown in the Halton region.

Location: Halton Region			
Nursery crop	**Common name**	**Container size**	**Optimal fertilizer rate/range kg N·m^{-3}**
Cornus alba 'Sibirica'	Tatarian dogwood	1 gal	0.65-1.25
Cornus sericea 'Kelseyi'	Kelsey's dwarf dogwood	1 gal	ND[a]-1.3
Cotoneaster dammeri 'Coral Beauty'	Bearberry cotoneaster	1 gal	0.65-1.25
Euonymus fortunei 'Golden Harlequin'	Golden Harlequin euonymus	1 gal	ND[a]-1.3
Euonymus fortunei 'Surespot'	Surespot euonymus	1 gal	0.65-1.25
Forsythia x intermedia 'Gold Tide'	Gold Tide forsythia	1 gal	0.65-1.25
Thuja plicata 'Whipcord'	Whipcord western red cedar	1 gal	1.3-3.2
Weigela florida 'Variegata'	Weigela	1 gal	0.65-1.25
Buxus ‘Green Mound'	Green Mound boxwood	2 gal	0.45
Rhus aromatica ‘Gro-Low’	Fragrant sumac	2 gal	0.75-1.35
Spiraea x bumalda 'Goldmound'	Goldmound spirea	2 gal	0.75-1.05
Syringa x 'Penda'	Bloomerang purple lilac	2 gal	1.05
Taxus x media ‘Runyan'	Runyan yew	2 gal	1.05
Thuja occidentalis ‘Emerald’	Emerald cedar	2 gal	0.45
Hibiscus syriacus 'Sugar Tip'	Sugar Tip Rose of Sharon	5 gal	0.30 -0.46
Hydrangea paniculata 'Limelight'	Limelight hydrangea	5 gal	0.30 -0.46

[a]ND - Not Determined, due to minimal growth response

Halton Region Nursery

Fertilizer:

1 gal (2012 and 2013) and 2 gal (2013 deciduous species) - Polyon 19-04-10, 8-9 month

2 gal (2013 evergreen species) - Polyon 15-06-11, 10-12 month

Growing Substrate:

Gro-Bark Shrub Mix

Trial Dates:

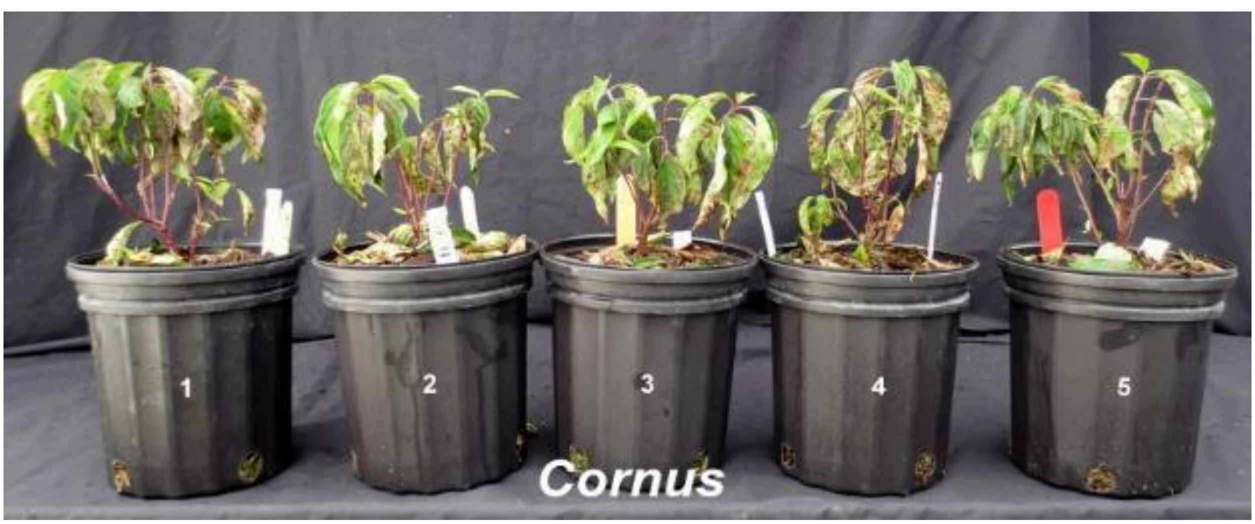
- **1-gal containers** (2012 trial: July 9th – October 5th; June 3rd winter injury evaluation)
- **1-gal containers** (2013 trial: May 23rd – August 23rd)
- **2-gal containers** (2013 trial: May 23rd – September 10th)

The following are the growth performance results:

1 gal trial (2012)

Fertilizer rates incorporated:

Treatment :	1	2	3	4	5	Unit
	1.25	1.74	2.24	2.74	3.24	kg N·m^{-3}
	2.11	2.93	3.78	4.62	5.46	lb N·yd^{-3}
	11.09	15.44	19.87	24.31	28.74	lb fertilizer·yd^{-3}

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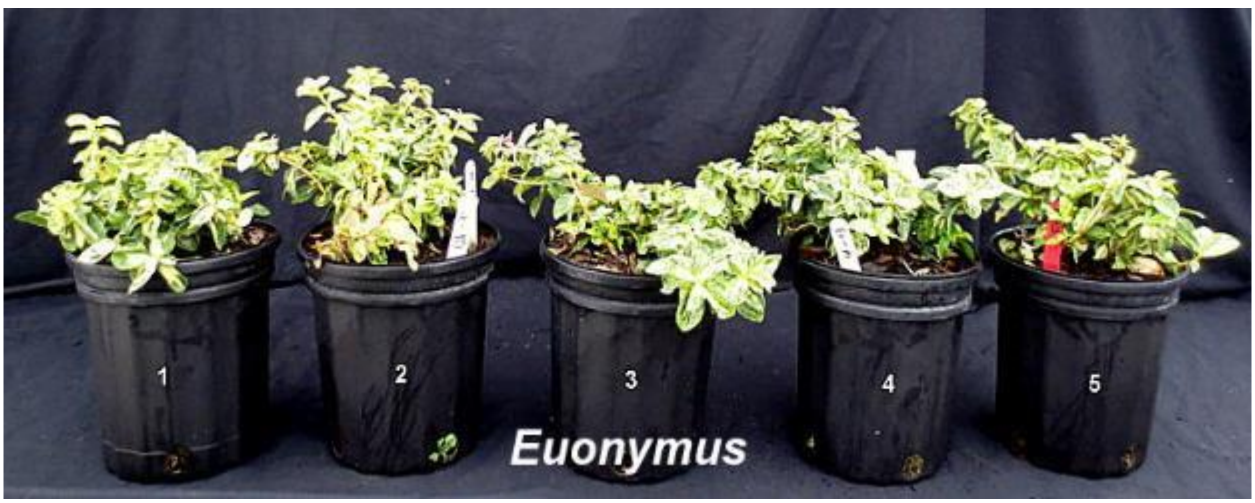
Cotoneaster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Euonymus


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Forsythia


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Thuja


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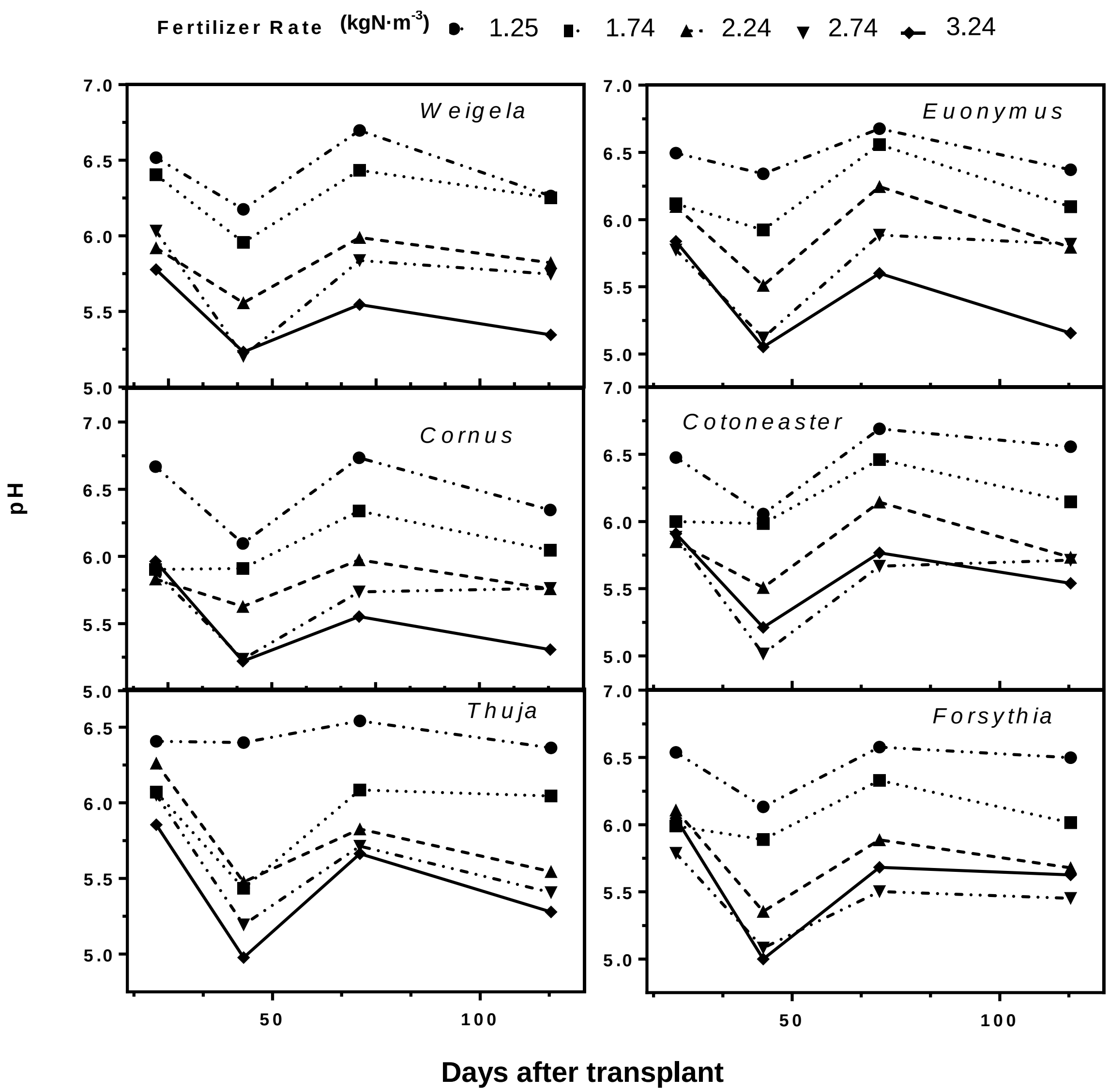
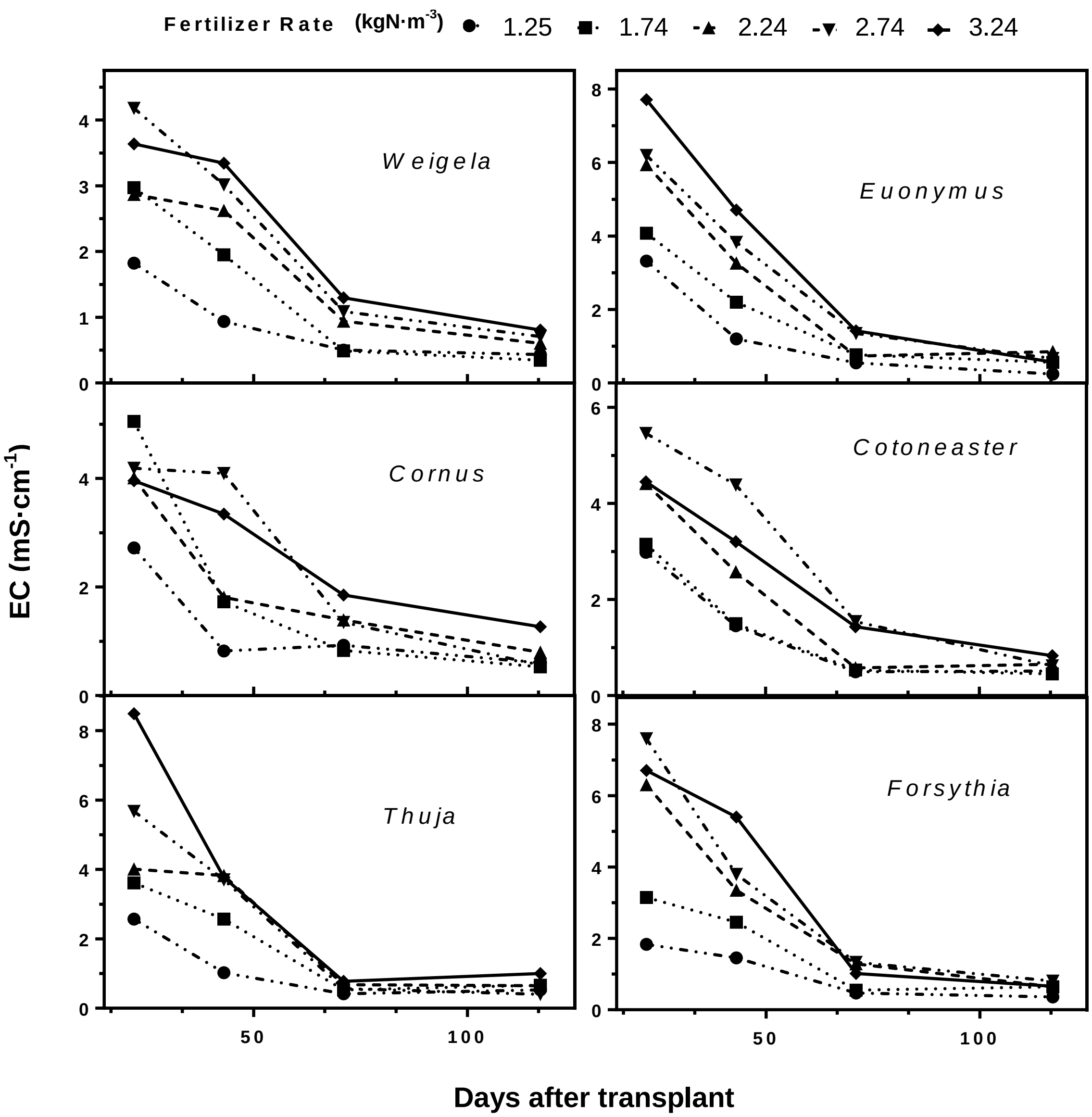
Weigela

Substrate pH over time (1 gal 2012)



Substrate EC over time (1 gal 2012)

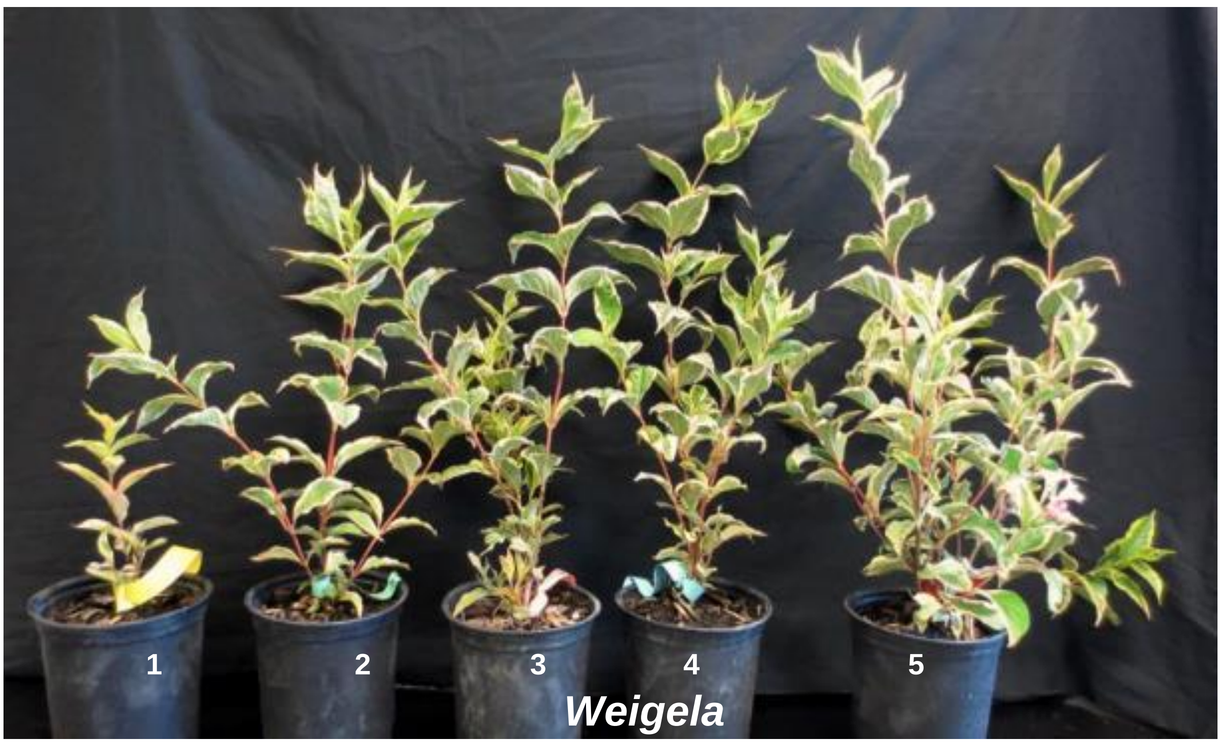


<u>Halton Region Nursery</u>

<u>1 gal trial (2013)</u>

<u>Fertilizer rates incorporated:</u>

Treatment :	1	2	3	4	5	Unit
	0.05	0.35	0.65	0.95	1.25	kg N·m^{-3}
	0.08	0.59	1.10	1.60	2.11	lb N·yd^{-3}
	0.44	3.10	5.77	8.43	11.09	lb fertilizer·yd^{-3}

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Cornus


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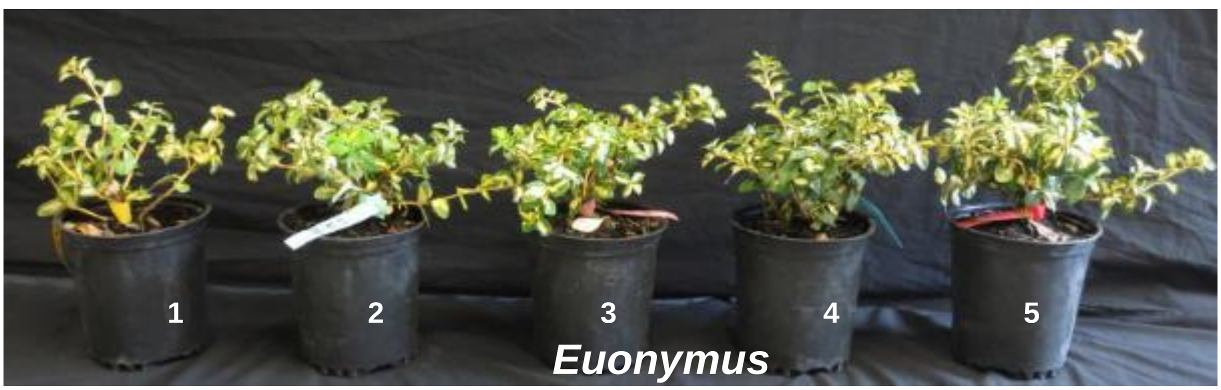
Cotoneaster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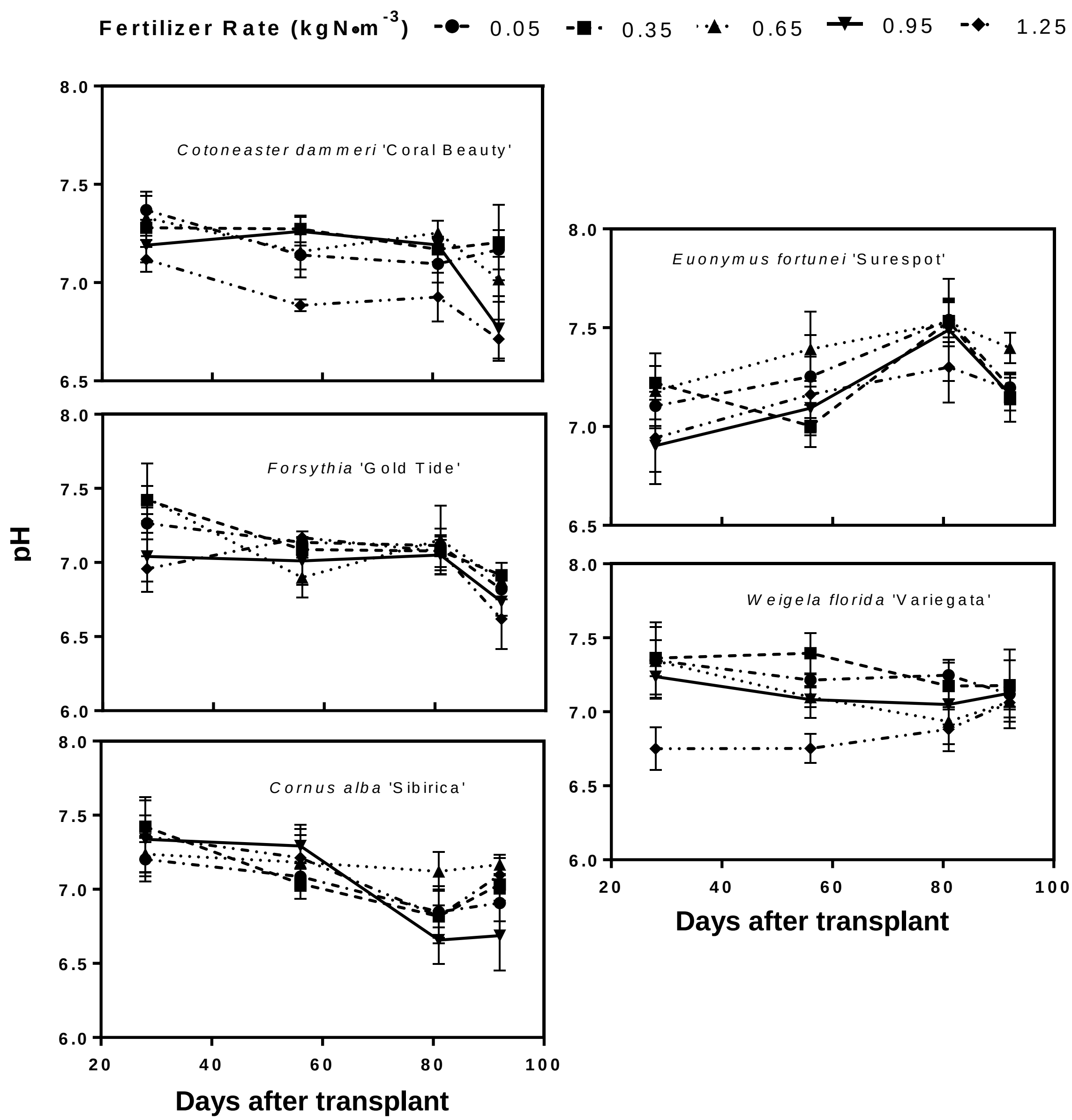
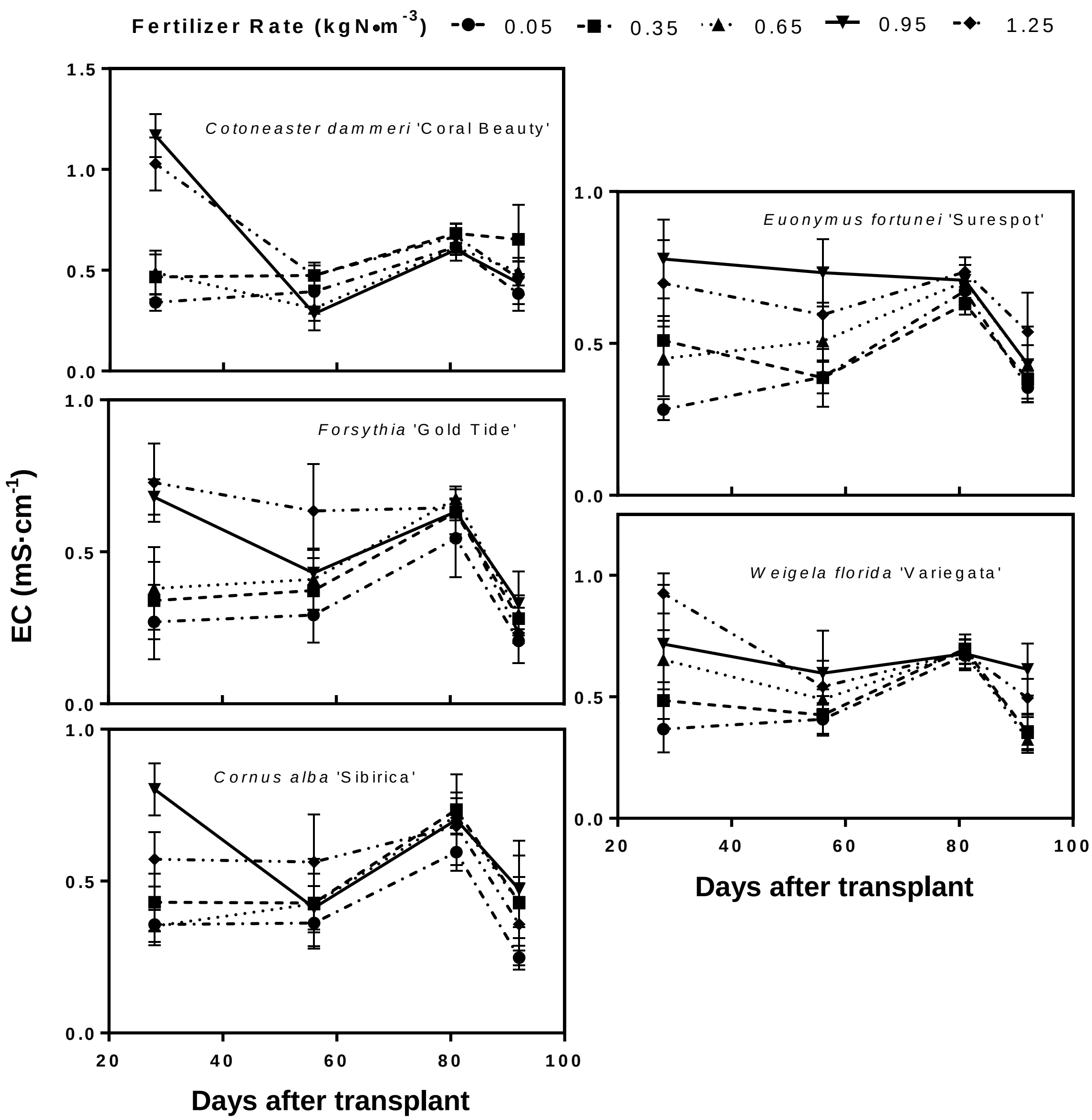
Euonymus

Substrate pH over time (1 gal 2013)



Substrate EC over time (1 gal 2013)



Halton Region Nursery

2 gal trial (2013)

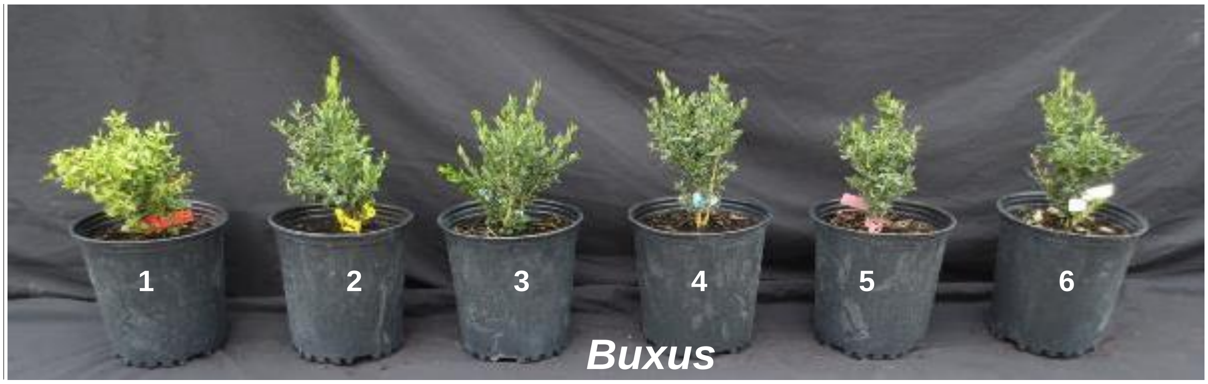
Fertilizer rates incorporated:

Deciduous: Polyon 19-04-10, 8-9 month

Treatment :	1	2	3	4	5	6	Unit
	0.15	0.45	0.75	1.05	1.35	1.65	kg $N \cdot m^{-3}$
	0.25	0.76	1.26	1.77	2.28	2.78	lb $N \cdot yd^{-3}$
	1.33	3.99	6.65	9.31	11.98	14.64	lb fertilizer$\cdot yd^{-3}$

Evergreen: Polyon 15-06-11, 10-12 month

Treatment :	1	2	3	4	5	6	Unit
	0.15	0.45	0.75	1.05	1.35	1.65	kg $N \cdot m^{-3}$
	0.25	0.76	1.26	1.77	2.28	2.78	lb $N \cdot yd^{-3}$
	1.69	5.06	8.43	11.80	15.17	18.64	lb fertilizer$\cdot yd^{-3}$

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Spirea


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Syringa


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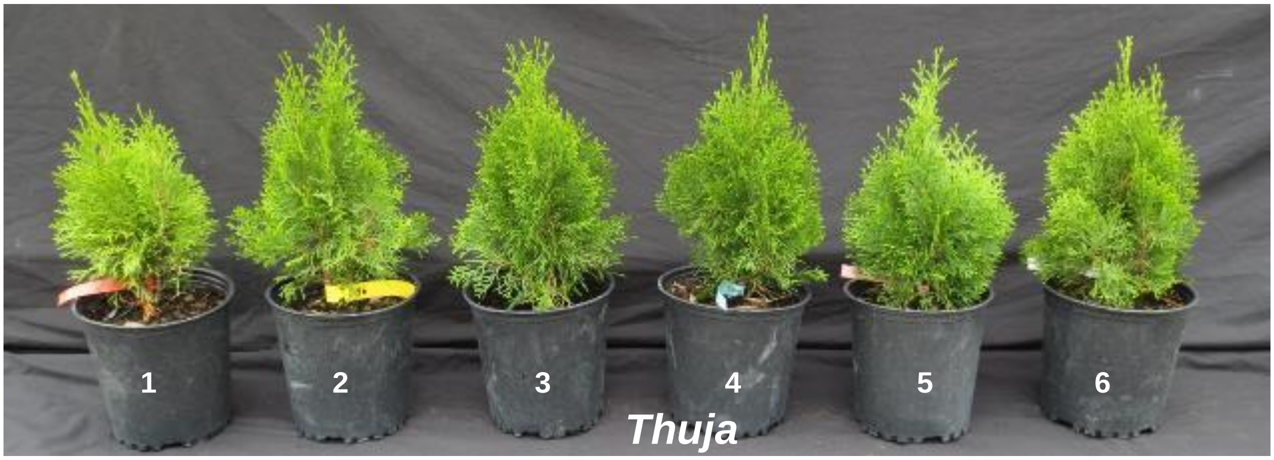
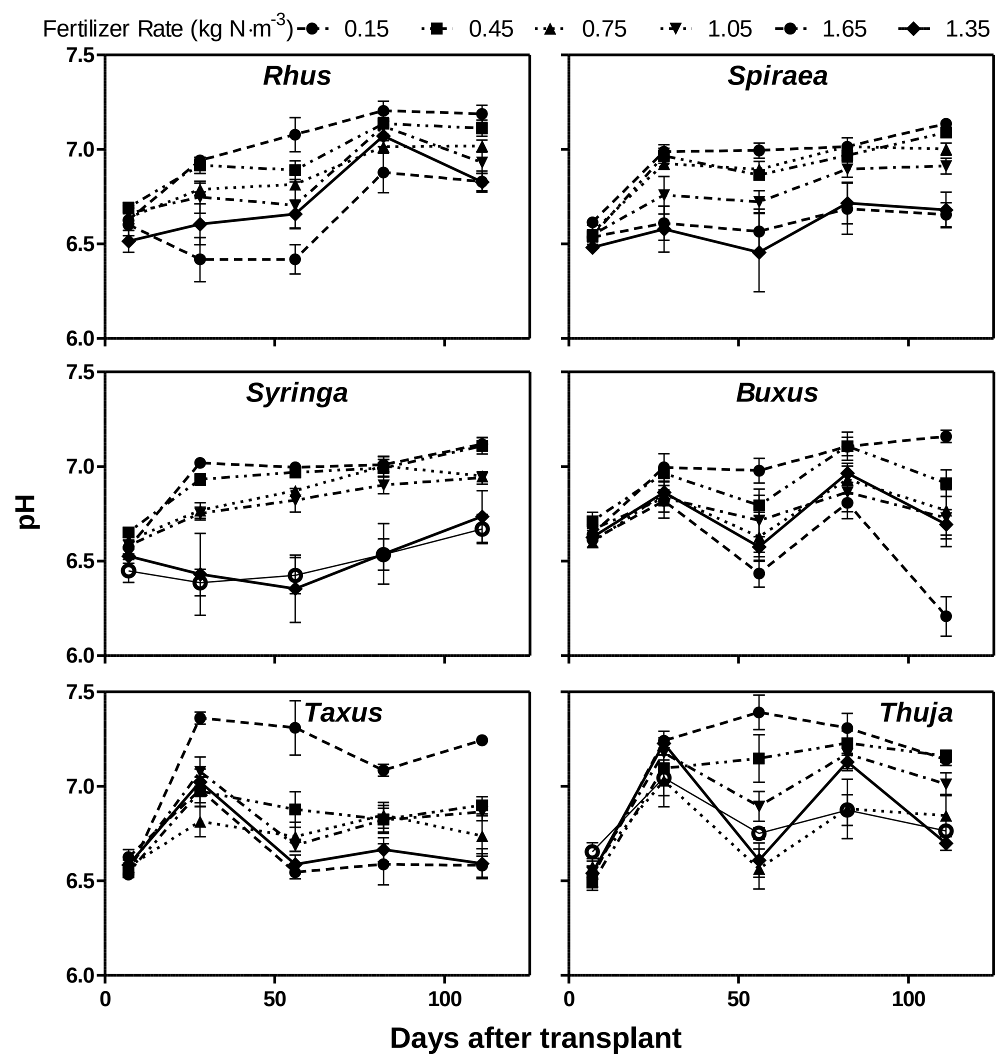
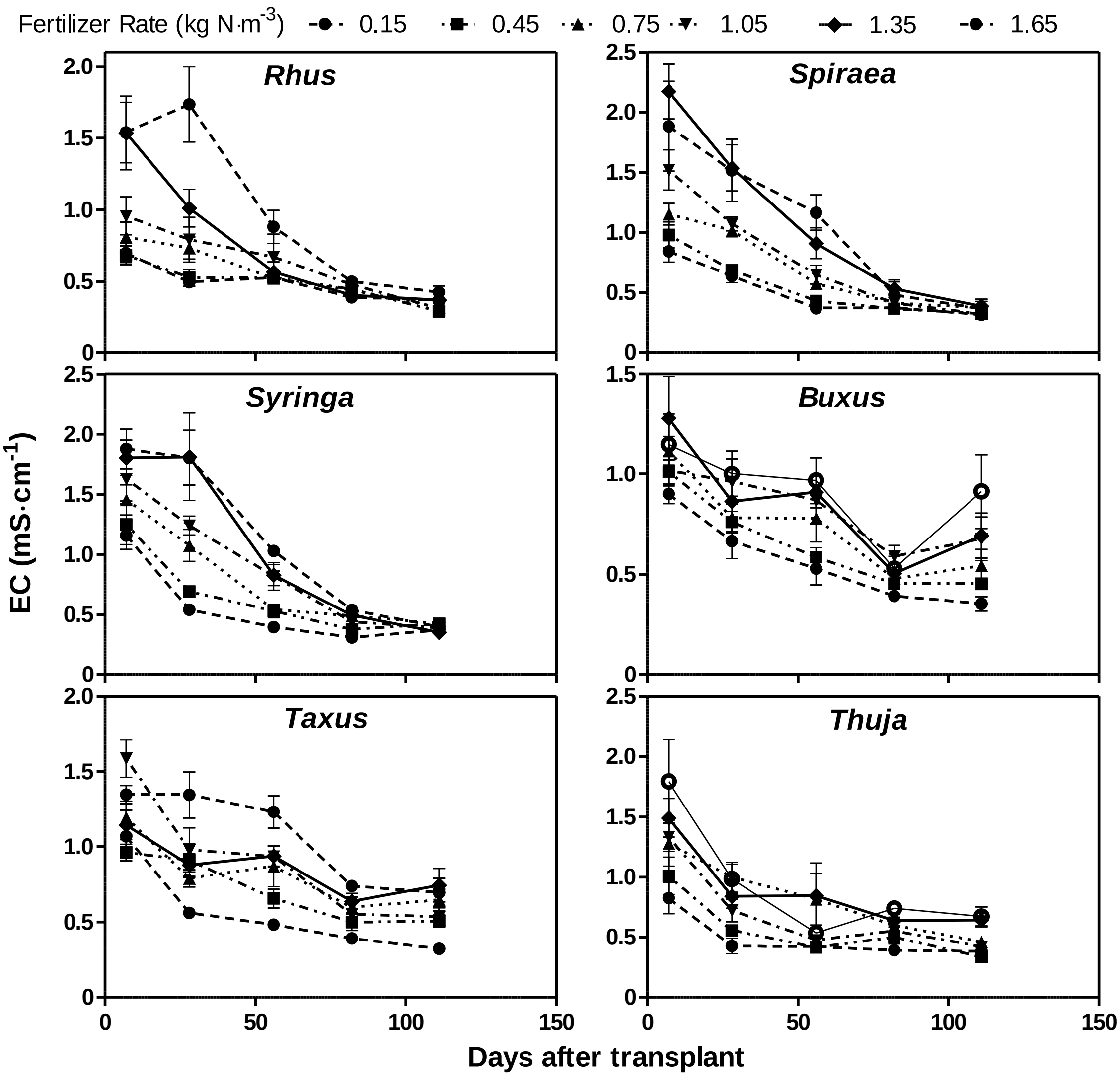
Taxus



Substrate pH over time (2 gal 2013)



Substrate EC over time (2 gal 2013)



Halton Region Nursery

Fertilizer: Polyon 19-6-13, 8-9 month incorporated at potting on April 18, 2018 (at 4.16 kg N·m^{-3}) followed by topdressing on June 4, 2015 with either Polyon 16-6-12, 4 month or Multicote 18-6-12, 4 month.

Growing Substrate: Composted pine bark, aged bark blend, softwood fines, compost

Trial Dates: April – August, 2015

- **5-gal containers**

Fertilizer rates topdressed:

Treatment :	1	2	3	4	5	6	7	Unit
	0.0	0.08	0.15	0.23	0.30	0.38	0.46	kg N·m^{-3}
	0.0	0.13	0.25	0.39	0.51	0.64	0.78	lb N·yd^{-3}
Polyon	0.0	0.81	1.56	2.44	3.19	4.00	4.85	lb fertilizer·yd^{-3}
Multicote	0.0	0.72	1.39	2.17	2.83	3.56	4.33	lb fertilizer·yd^{-3}

The following are the growth performance results:

***Hydrangea paniculata* 'Limelight', July (top) and August (bottom) 2015, with Polyon**

***Hydrangea paniculata* 'Limelight', July (top) and August (bottom) 2015, with Multicote**

***Hibiscus syriacus* 'Sugar tip', July (top) and August (bottom) 2015, with Polyon**

Hibiscus syriacus **'Sugar tip', July (top) and August (bottom) 2015, with Multicote**

Research Result Summary: Niagara Region

Table 3. Summary of optimal fertilizer rates and/or ranges per nursery crop grown in the Niagara region.

Location: Niagara Region			
Nursery crop	**Common name**	**Container size**	**Optimal fertilizer rate/range kg N·m^{-3}**
Buxus 'Green Velvet'	Green Velvet boxwood	6 inch	ND[a]
Buxus 'Green Velvet'	Green Velvet boxwood	1 gal	0.95-2.9
Hemerocallis 'Stella d'Oro'	Stella d'Oro daylily	1 gal	0.65-0.95
Heuchera 'Red Lightning'	Red Lightning coral bells	1 gal	1.19
Hibiscus syriacus 'Woodbridge'	Woodbridge Rose of Sharon	1 gal	0.65-0.95
Hydrangea macrophylla 'Penny Mac'	Penny Mac hydrangea	1 gal	0.95-1.25
Miscanthus sinensis 'Zebrinus'	Zebra grass	1 gal	1.38
Spiraea japonica 'Magic Carpet'	Magic Carpet spirea	1 gal	0.95-2.4
Syringa meyeri 'Palibin'	Dwarf Korean lilac	1 gal	0.35
Berberis thunbergii 'Concorde'	Concorde barberry	2 gal	1.35
Buxus 'Green Velvet'	Green Velvet boxwood	2 gal	0.75-1.35
Buxus 'Green Velvet'	Green Velvet boxwood	2 gal	1.40[b]
Cornus alba 'Bailhalo'	Ivory Halo dogwood	2 gal	1.65
Euonymus alatus 'Compactus'	Dwarf winged euonymus	2 gal	0.45
Heuchera 'Palace Purple'	Palace Purple coral bells	2 gal	0.75
Hibiscus syriacus	Rose of Sharon	2 gal	1.05-1.35
Hydrangea macrophylla	Bigleaf hydrangea	2 gal	0.75-1.35
Hydrangea macrophylla 'Paraplu'	Paraplu hydrangea	2 gal	ND[c]
Potentilla fruticosa 'Gold Star'	Gold Star potentilla	2 gal	1.05
Rhododendron 'P.J.M.'	P.J.M. rhododendron	2 gal	1.35
Rhododendron 'Pearce's American Beauty'	Pearce's American Beauty rhododendron	2 gal	1.38
Spirea japonica 'Magic Carpet'	Magic Carpet spirea	2 gal	0.75-1.05
Syringa meyeri 'Palibin'	Dwarf Korean lilac	2 gal	ND[a]
Buxus 'Green Velvet'	Green Velvet boxwood	3 gal	1.00[d]
Hydrangea macrophylla 'Endless Summer'	Endless Summer hydrangea	3 gal	7.0[e]
Hydrangea macrophylla 'Wedding Gown'	Wedding Gown hydrangea	3 gal	0.79
Taxus x media 'Densiformis'	Dense yew	3 gal	1.00-1.40[f]
Taxus x media 'Hillii'	Hill's yew	3 gal	1.40[g]
Vaccinium corymbosum 'Duke'	Duke highbush blueberry	5 gal	0.3-0.5[h]; 0.5-0.9[i]; or 12.2-14.7[j]

[a]ND - Not Determined, due to minimal growth response

[b]8-9 month for single application (topdress or incorporated), 5-6 month for split application (topdress or incorporated)

[c]Rate of Blue Max coated Aluminum Sulfate, Not Determined, due to minimal flower colour response

[d]Either 5-6 month or 8-9 month fertilizer duration, split application

[e]Rate of Blue Max coated Aluminum Sulfate (14S, 13.8 Al); g·L^{-1}

[f]8-9 month fertilizer duration, split application

[g]8-9 month for split application (topdress or incorporated) and single application (topdress), 5-6 month for single application (incorporated)

[h]Conventional controlled-release fertilizer

[i]Granular organic fertilizer

[j]Liquid organic fertilizer; mmol·L^{-1} N

Niagara Region Nursery

Fertilizer:

Polyon 19-06-13, 8-9 month

Growing Substrate:

Niagara Region Nursery Standard Media

Trial Dates:

- **1-gal containers** (2012 trial: June 29th – October 2nd; June 7th winter injury evaluation)
- **1-gal containers** (2013 trial: May 27th – August 19th)
- **2-gal containers** (2013 trial: May 15th – September 13th)

The following are the growth performance results:

1 gal trial (2012)

Fertilizer rates incorporated:

Treatment :	1	2	3	4	5	Unit
	1.32	1.85	2.38	2.91	3.44	kg N·m^{-3}
	2.23	3.12	4.01	4.90	5.79	lb N·yd^{-3}
	11.72	16.41	21.10	25.79	30.48	lb fertilizer·yd^{-3}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Hemerocallis


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Hibiscus


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Hydrangea


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Spirea
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Syringa
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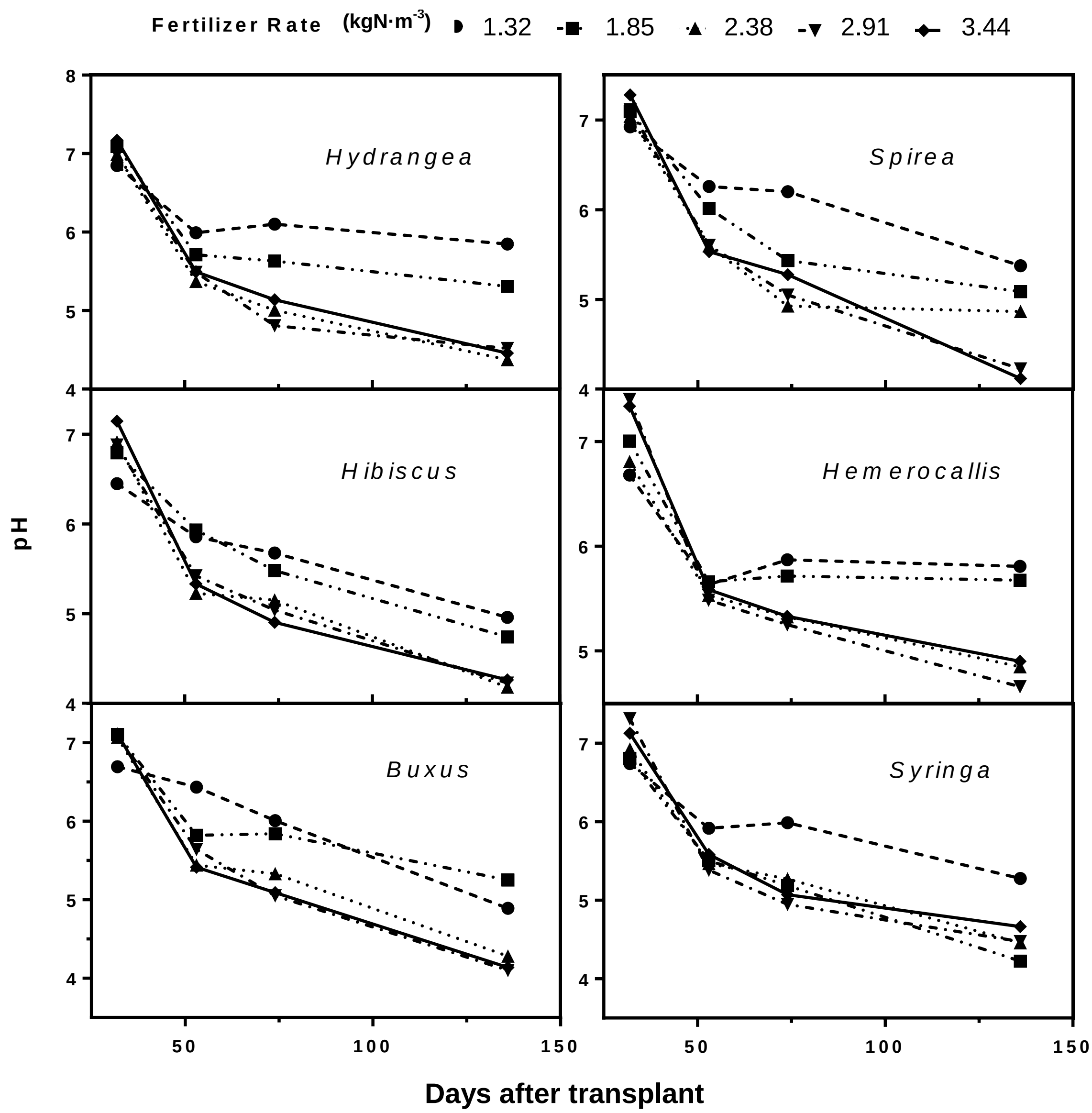
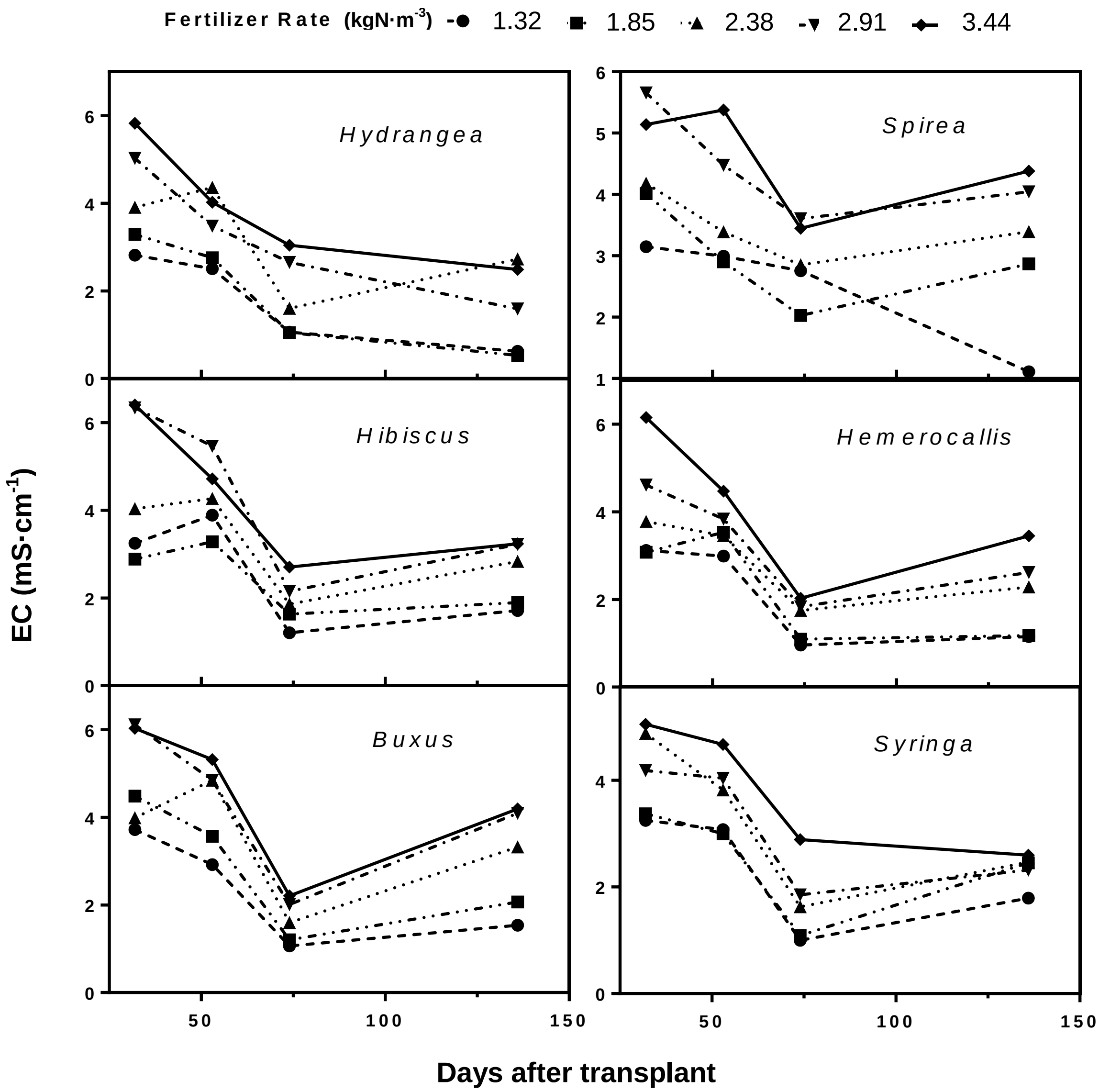
Substrate pH over time (1 gal 2012)



Substrate EC over time (1 gal 2012)

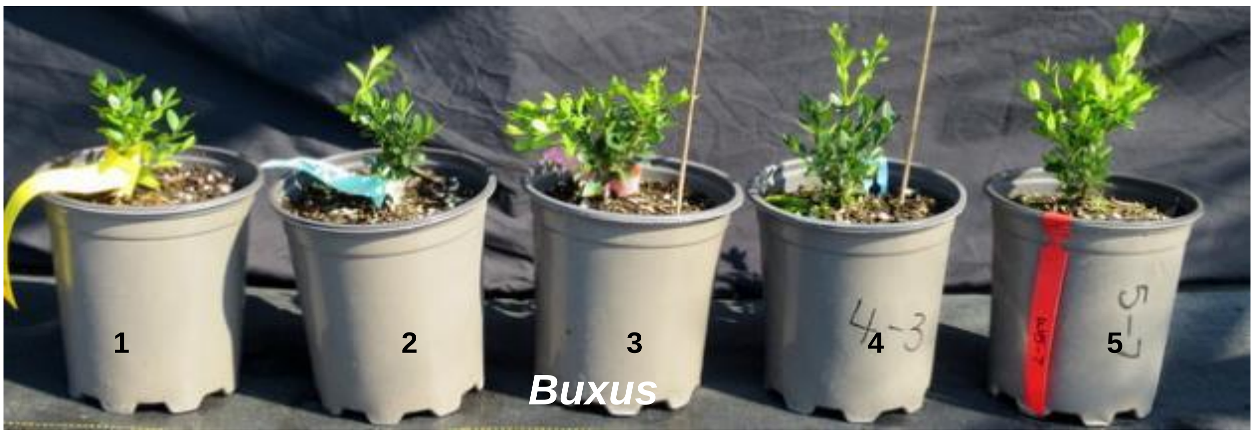


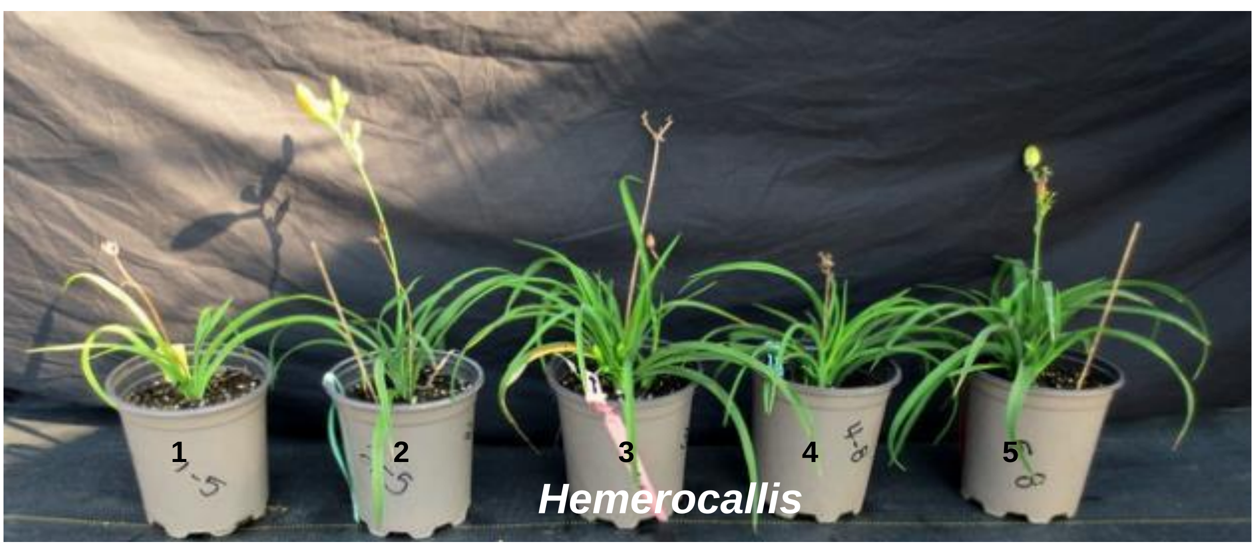
Niagara Region Nursery

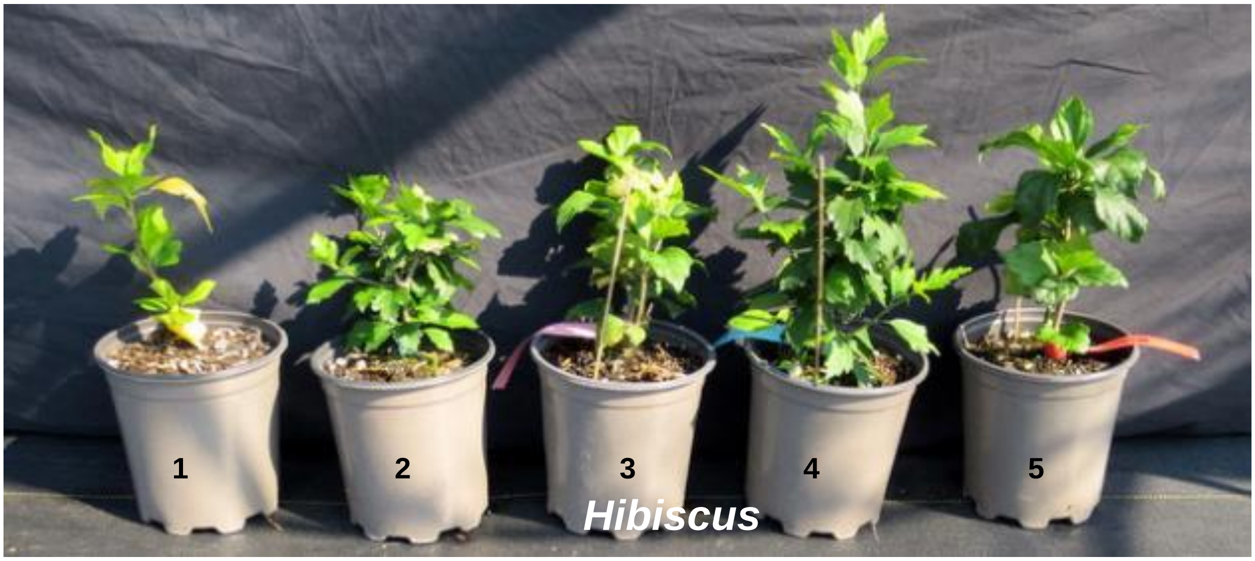
1 gal trial (2013)

Fertilizer rates incorporated:

Treatment :	1	2	3	4	5	Unit
	0.05	0.35	0.65	0.95	1.25	kg N·m^{-3}
	0.08	0.59	1.10	1.60	2.11	lb N·yd^{-3}
	0.44	3.10	5.77	8.43	11.09	lb fertilizer·yd^{-3}



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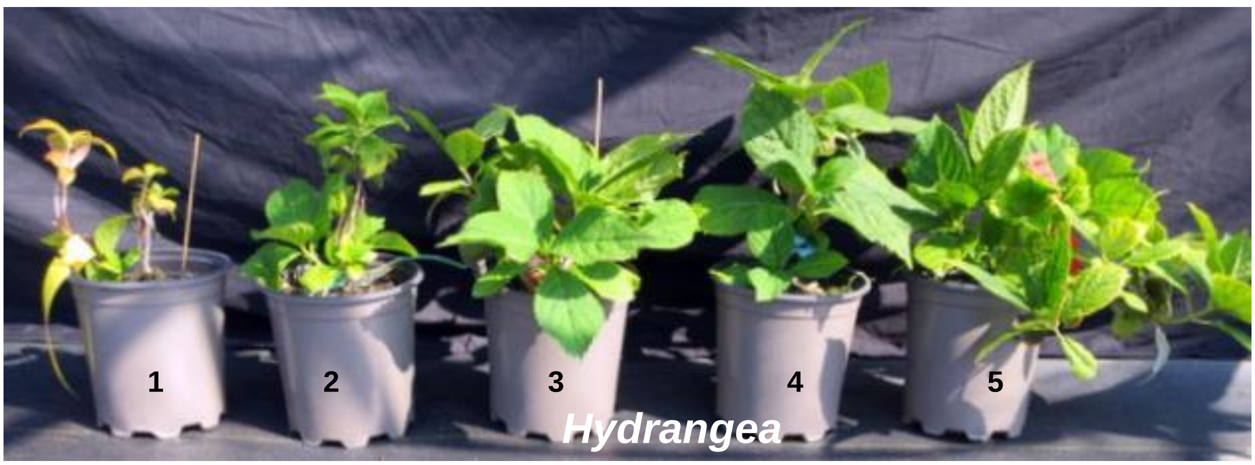
Hibiscus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Hydrangea


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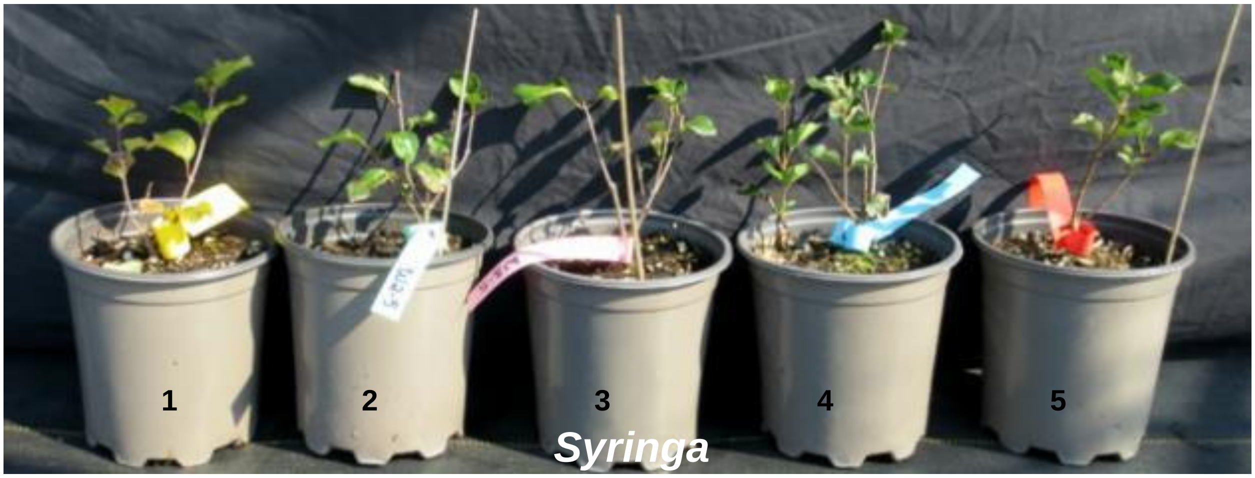
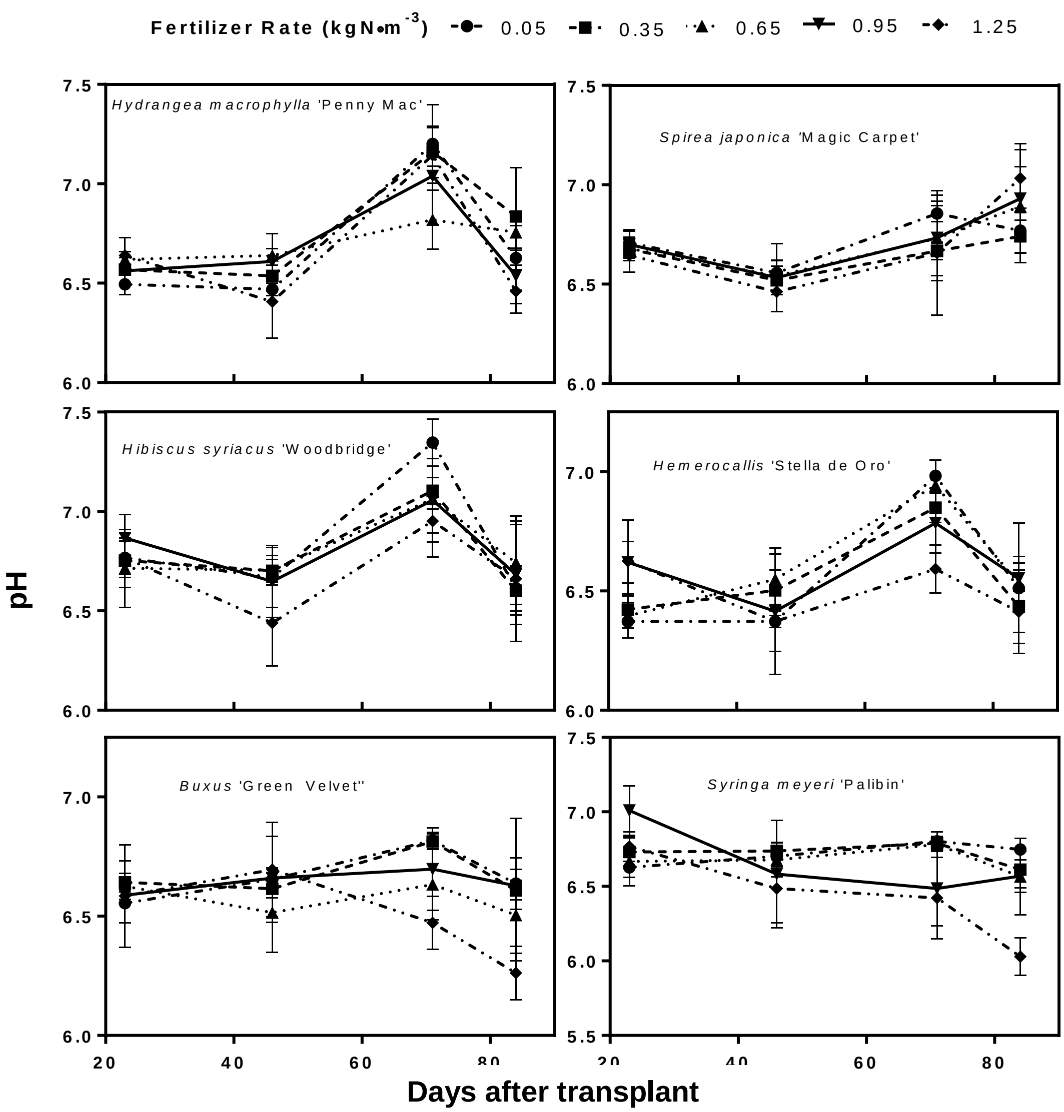
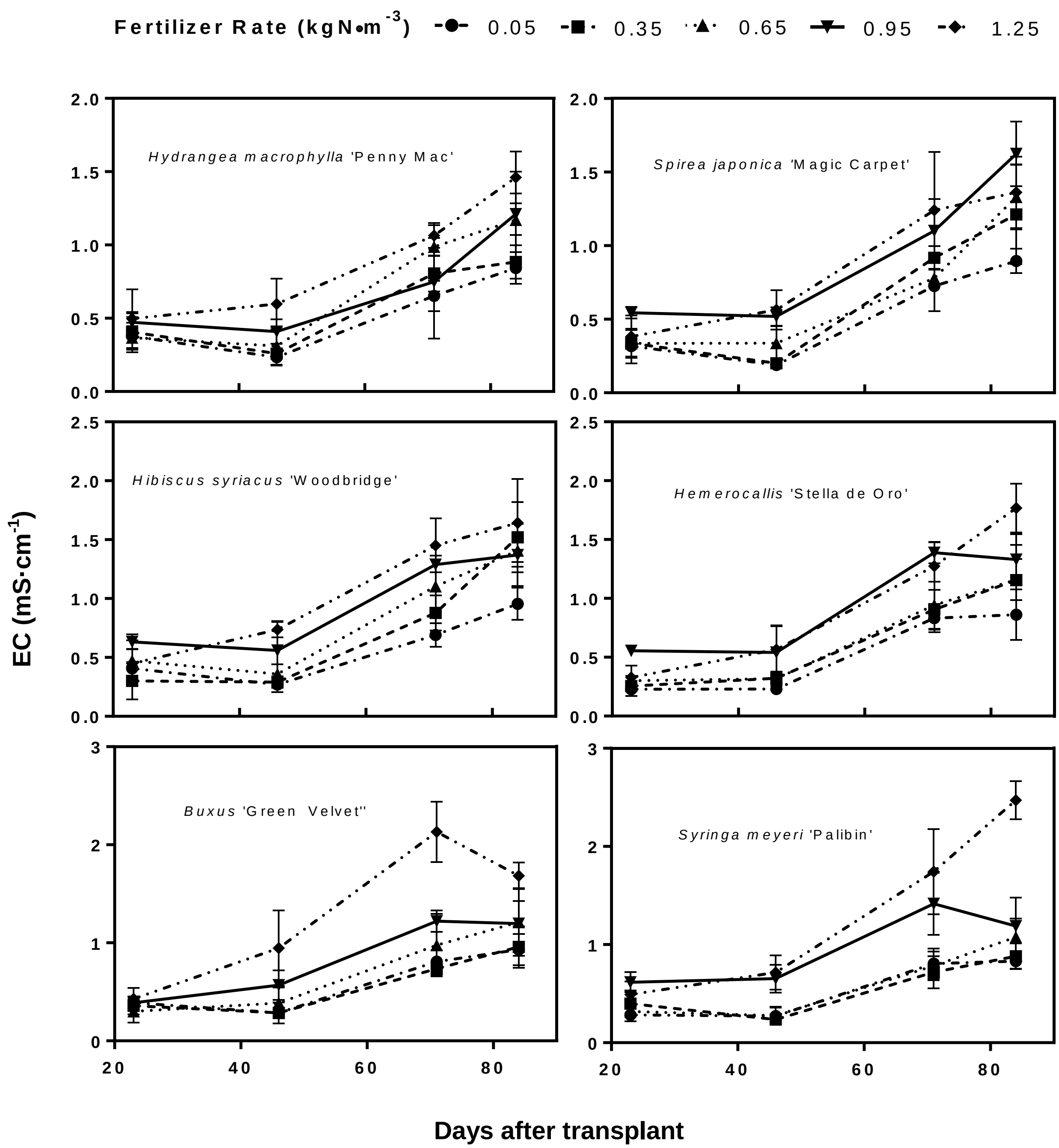
Spirea



Substrate pH over time (1 gal 2013)



Substrate EC over time (1 gal 2013)

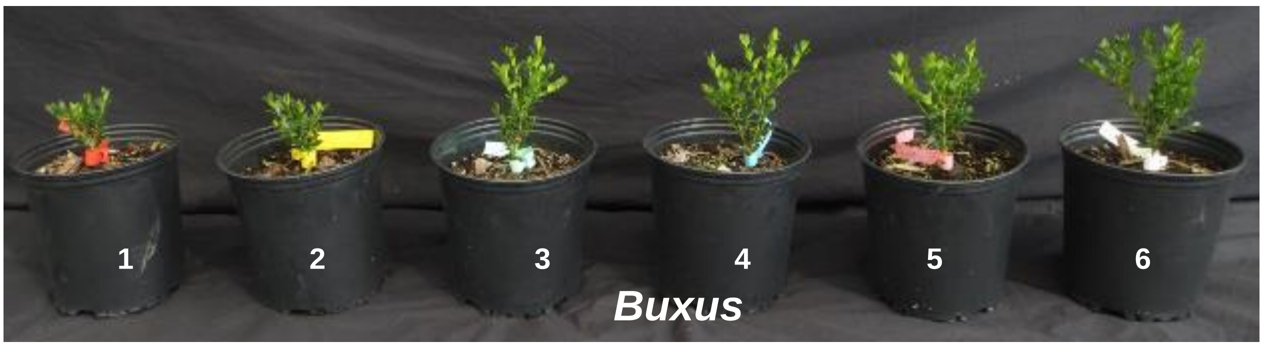


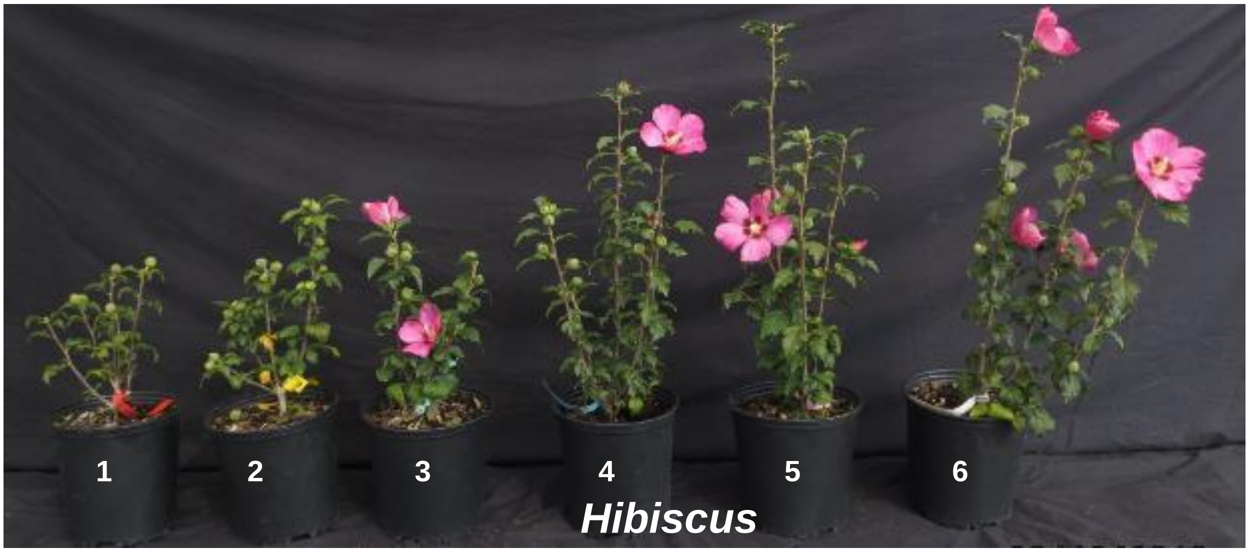
Niagara Region Nursery

2 gal trial (2013)

Fertilizer rates incorporated:

Treatment :	1	2	3	4	5	6	Unit
	0.15	0.45	0.75	1.05	1.35	1.65	kg N·m^{-3}
	0.25	0.76	1.26	1.77	2.28	2.78	lb N·yd^{-3}
	1.33	3.99	6.65	9.31	11.98	14.64	lb fertilizer·yd^{-3}

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Hibiscus


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Spirea


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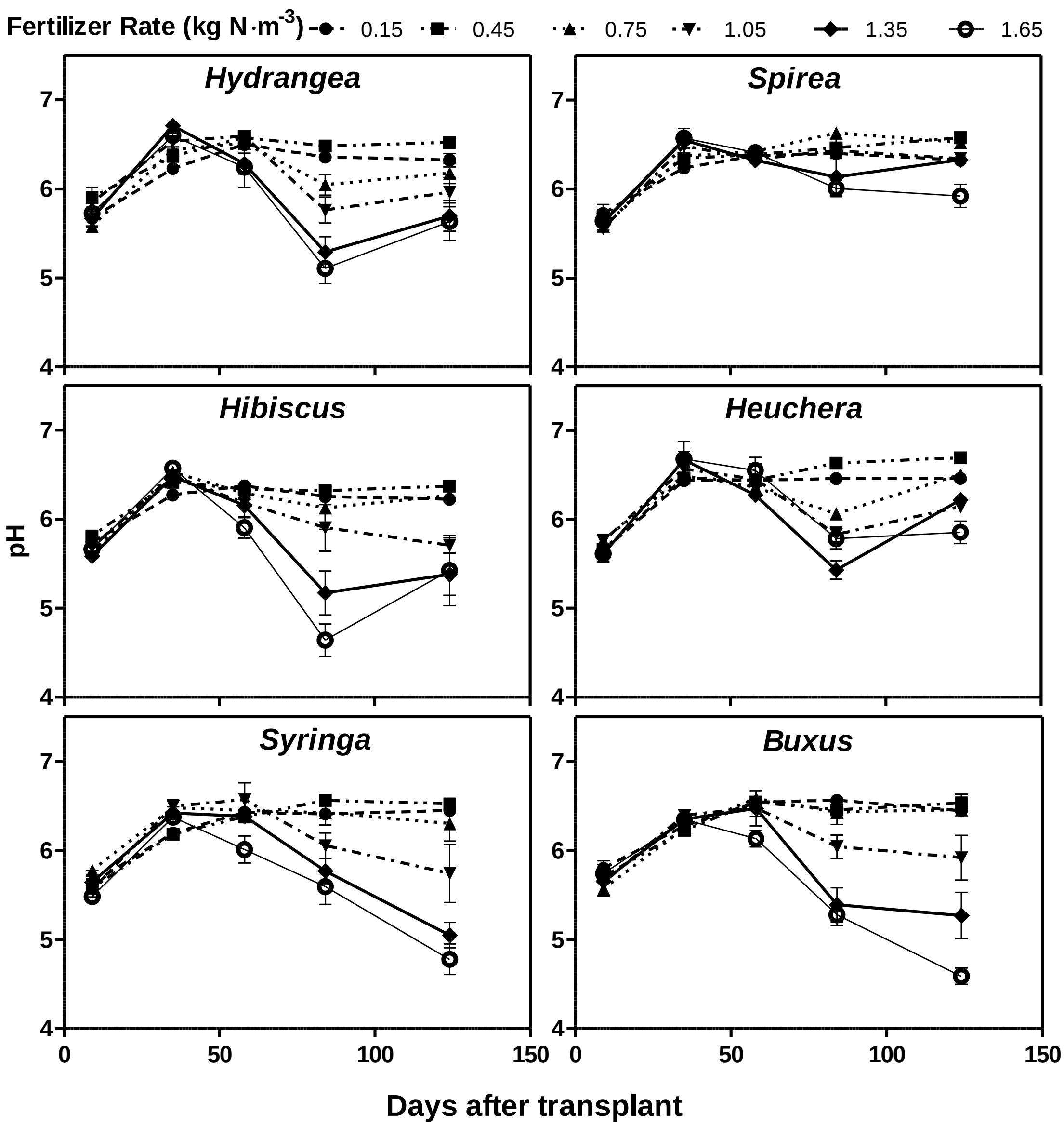
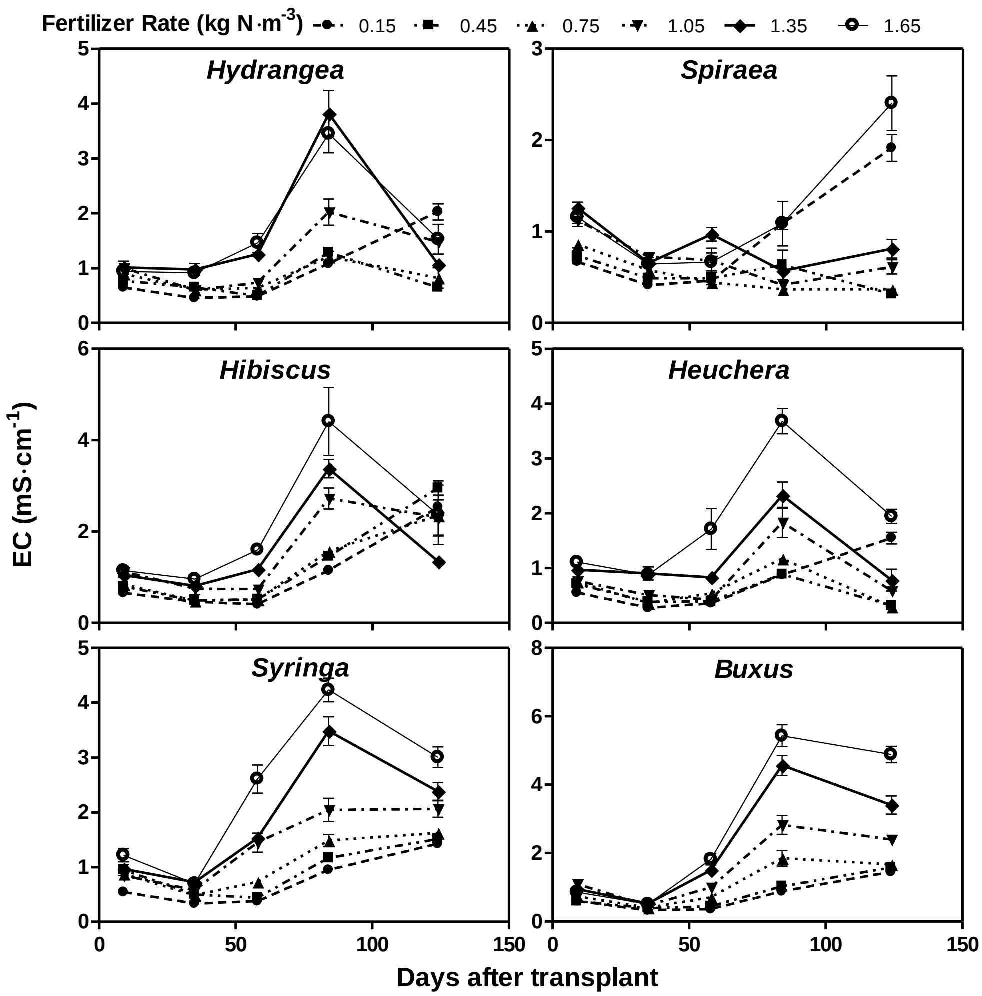
Syringa

Substrate pH over time (2 gal 2013)



Substrate EC over time (2 gal 2013)



Niagara Region Nursery (Beamsville)

Fertilizer: Osmocote Plus 15-9-12, 5-6 month, topdressed.

Growing Substrate: Gro-Bark custom nursery blend

Trial Dates (2017):

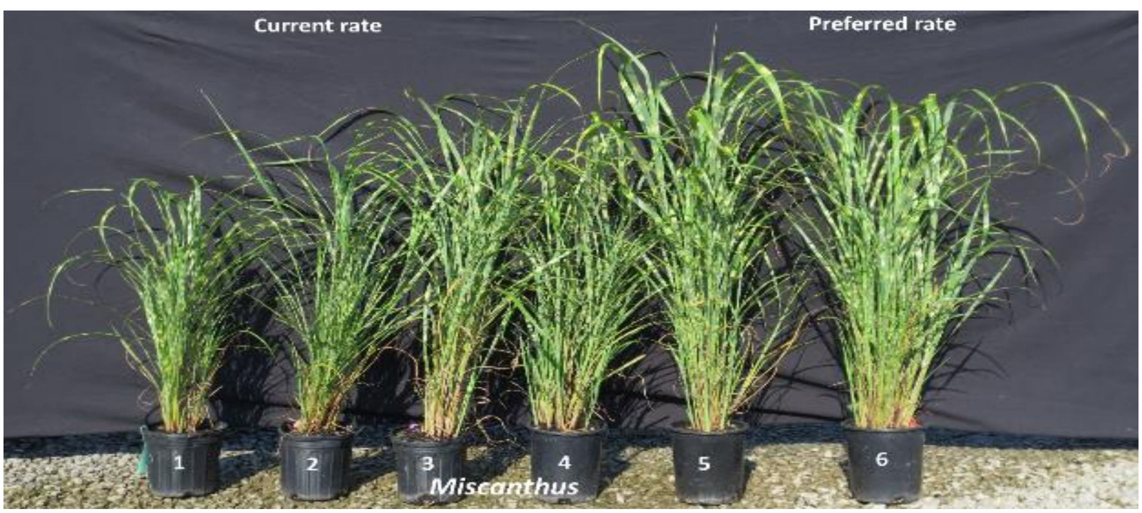
- 1- & 2-gal containers: June 1st – September 27th
- 3-gal containers: July 4th - September 27th

The following are the growth performance results:

1 gal trial (2017)

Fertilizer rates incorporated:

Treatment :	1	2	3	4	5	6	Unit
	0.40	0.59	0.79	0.99	1.19	1.38	kg $N \cdot m^{-3}$
	0.67	1.00	1.33	1.67	2.00	2.33	lb $N \cdot yd^{-3}$
	4.45	6.67	8.89	11.11	13.34	15.56	lb fertilizer$\cdot yd^{-3}$



2 gal trial (2017)

Fertilizer rates topdressed:

Treatment :	1	2	3	4	5	6	Unit
	0.51	0.71	0.91	1.07	1.27	1.48	kg N·m^{-3}
	0.86	1.2	1.54	1.8	2.14	2.49	lb N·yd^{-3}
	5.71	8.00	10.28	12.00	14.28	16.57	lb fertilizer·yd^{-3}

3 gal trial (2017)

Fertilizer rates topdressed:

Treatment :	1	2	3	4	5	6	Unit
	0.28	0.39	0.50	0.59	0.70	0.81	kg N·m^{-3}
	0.47	0.66	0.85	0.99	1.18	1.36	lb N·yd^{-3}
	3.14	4.39	5.64	6.59	7.84	9.09	lb fertilizer·yd^{-3}

Niagara Region Nursery (Fenwick)

Fertilizer: Polyon 19-6-13, 8-9 month incorporated.

Growing Substrate: Proprietary custom nursery blend.

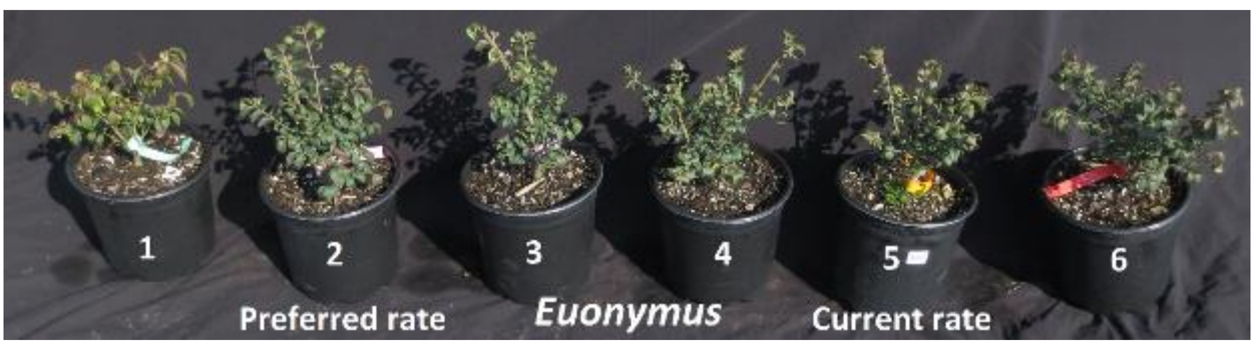
Trial Dates: 2-gal containers June 8 – September 25, 2017

The following are the growth performance results:

2 gal trial (2017)

Fertilizer rates incorporated:

Treatment :	1	2	3	4	5	6	Unit
	0.15	0.45	0.75	1.05	1.35	1.65	kg N·m^{-3}
	0.25	0.76	1.26	1.77	2.28	2.78	lb N·yd^{-3}
	1.33	3.99	6.65	9.31	11.98	14.64	lb fertilizer·yd^{-3}

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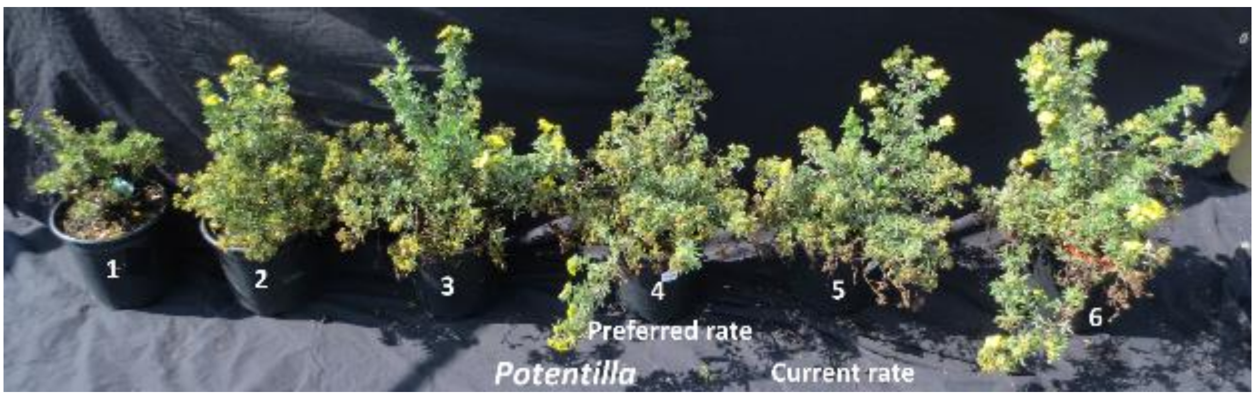
Cornus
Current rate
Preferred rate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Preferred rate
Potentilla
Current rate


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Rhododendron
Current & Preferred rate

Niagara Region Nursery (St. Catharines)

The objectives of this study were to determine the influence of the following on Green Velvet boxwood and dense yew summer growth and plant form:

1) Single and split dose (applying a low initial CRF rate and later re-applying additional CRF) topdress applications of CRF
2) CRF release duration (i.e., 5-6 month or 8-9 month) and application rate
3) Container colour (i.e., white vs. black) or adding additional potassium (K)

Fertilizer: Osmocote Plus 15-9-12, 5-6 month or 8-9 month, depending on treatment.

Growing Substrate: Proprietary custom nursery blend from Fafard Canada.

Trial Dates: June, 2016– August, 2017; 3-gal containers

The following are the growth performance results:

3 gal trial (2016-2017)

Fertilizer rates incorporated:

Treatment :	1	2	3	B	Unit
	0.60	1.00	1.40	0	kg N·m^{-3}
	1.01	1.69	2.36	0	lb N·yd^{-3}
	6.73	11.27	15.73	0	lb fertilizer·yd^{-3}

Boxwood

Single Application

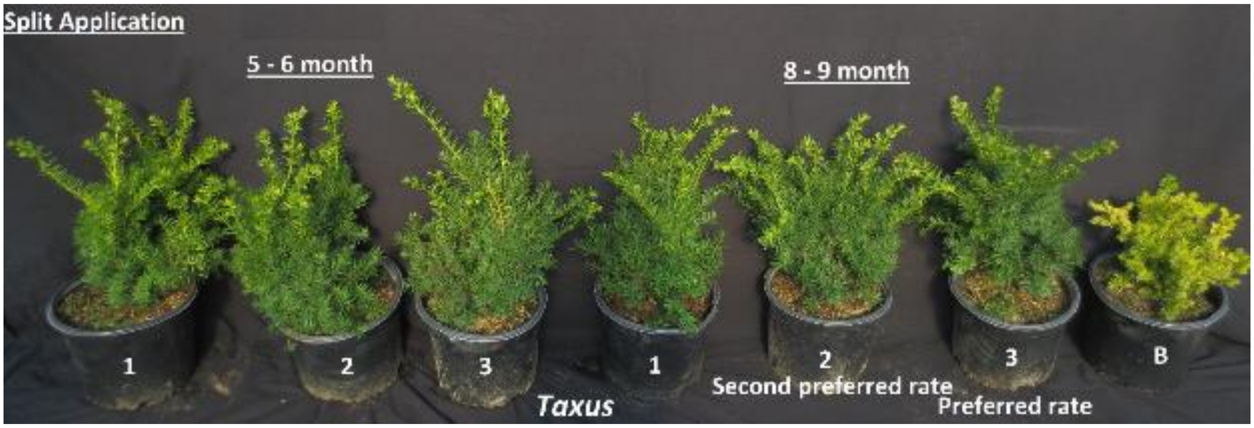
Split Application

Single Application Special Treatments (Extra K, White pot)

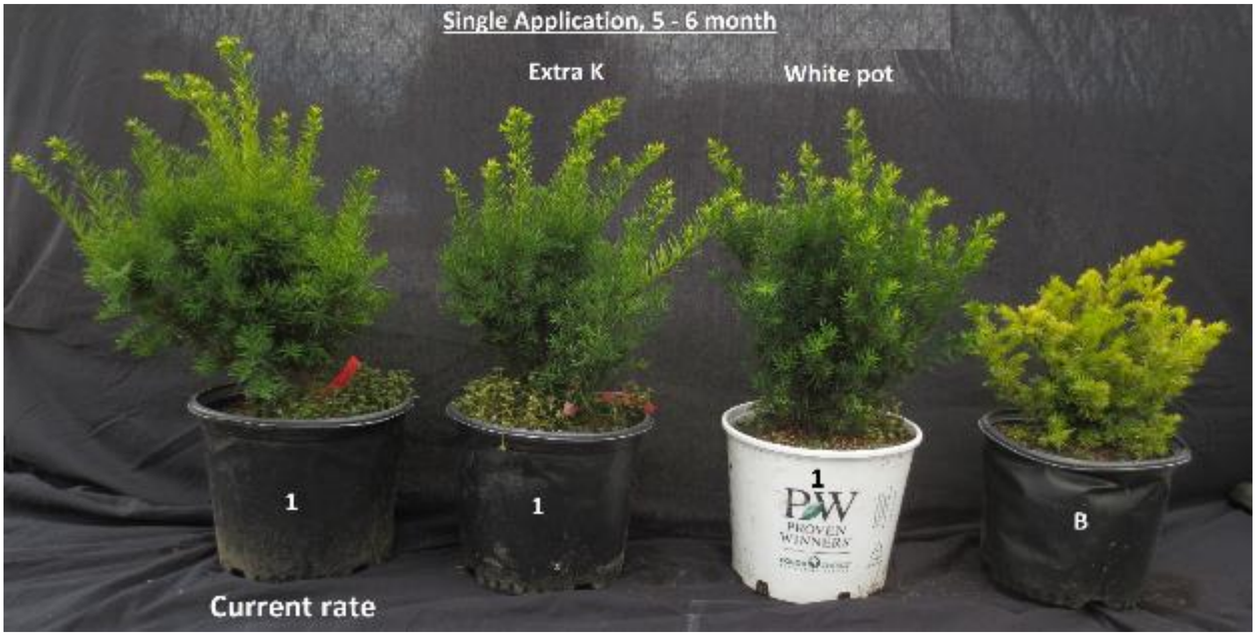
Yew

Single Application

Split Application



Single Application Special Treatments (Extra K, White pot)



Conclusions

The results of this study showed:

1) Split dose (applying a low initial CRF rate and later re-applying additional CRF) topdress applications of CRF were preferred to a single dose for both Green Velvet boxwood and dense yew.
2) When applied as a split dose application, either a 5-6 month or 8-9 month CRF release duration applied at 1.00 $kg \cdot m^{-3}$ N produced quality Green Velvet boxwood. For dense yew, the 8-9 month CRF release duration was preferred to the 5-6 month duration, when applied at 1.00-1.40 $kg \cdot m^{-3}$ N.
3) Container colour (i.e., white vs. black) or adding additional potassium (K) did not result in any growth improvements for either Green Velvet boxwood or dense yew, compared to current practices.

Niagara Region Nursery (Vineland)

The objectives of this study were to determine the influence of the following on Green Velvet boxwood and Hill's yew summer growth and plant form:

1) Incorporated and topdress CRF applications
2) Single and split dose (applying a low initial CRF rate and later topdressing additional CRF) applications of CRF
3) CRF release duration (i.e., 5-6 month or 8-9 month) and application rate
4) Container colour or adding additional potassium (K)

Fertilizer: Osmocote 18-5-12, 5-6 month or 8-9 month, depending on treatment.

Growing Substrate: Proprietary custom nursery blend from Fafard.

Trial Dates: June 2, 2016– August 22, 2017; 2 and 3-gal containers

The following are the growth performance results:

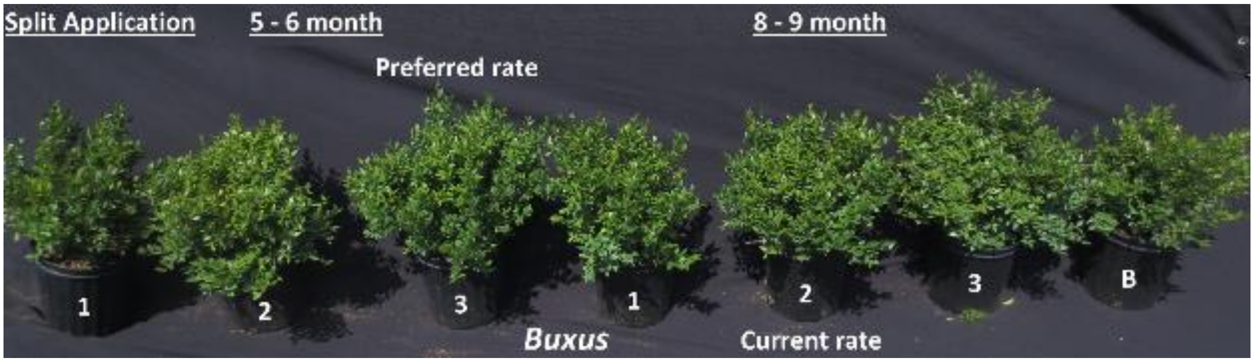
Fertilizer rates incorporated:

Treatment :	1	2	3	B	Unit
	0.60	1.00	1.40	0.00	kg $N \cdot m^{-3}$
	1.01	1.69	2.36	0.00	lb $N \cdot yd^{-3}$
	5.61	9.39	13.11	0.00	lb fertilizer$\cdot yd^{-3}$

2 gal trial (2016-2017)

Topdressed, Single Application

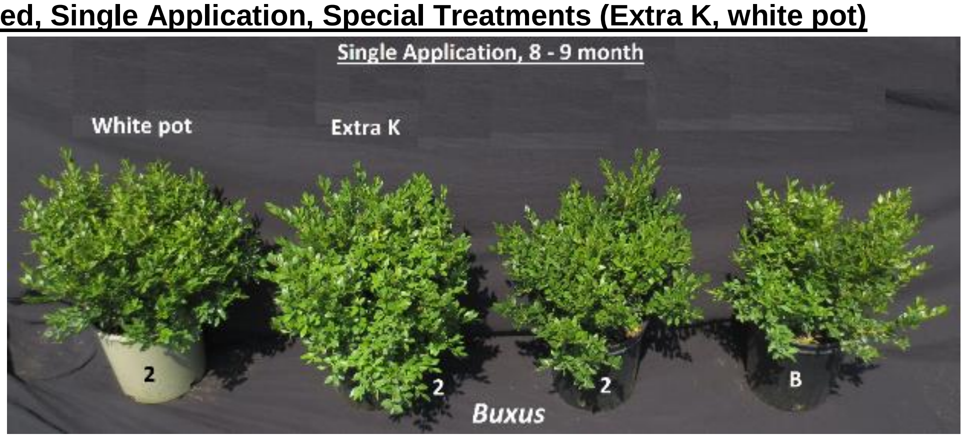
Topdressed, Split Application



Incorporated, Single Application

Incorporated, Split Application

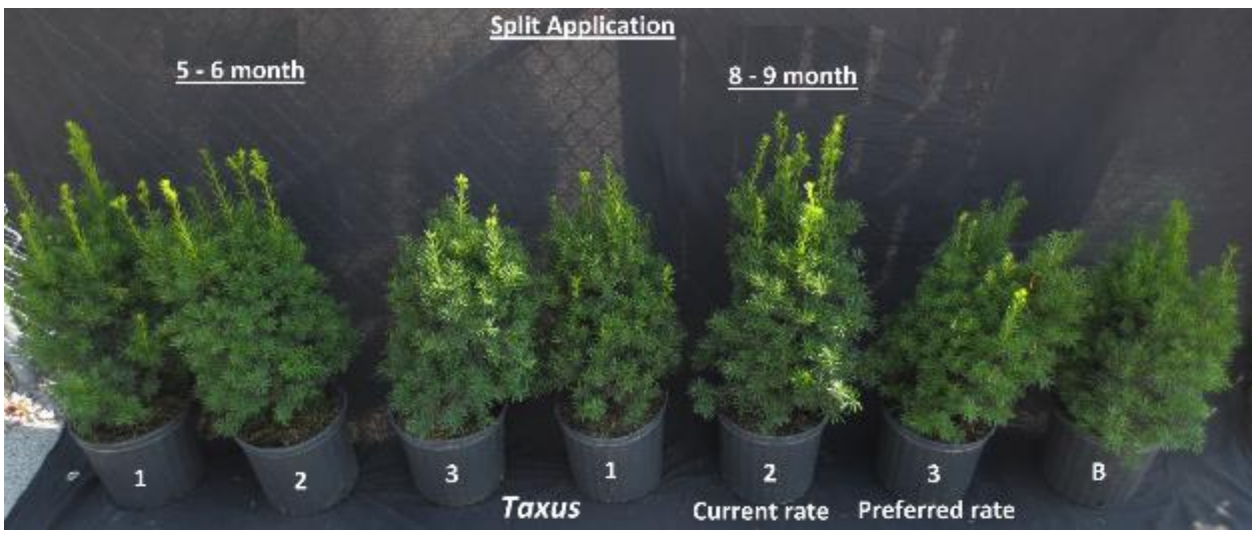
Incorporated, Single Application, Special Treatments (Extra K, white pot)



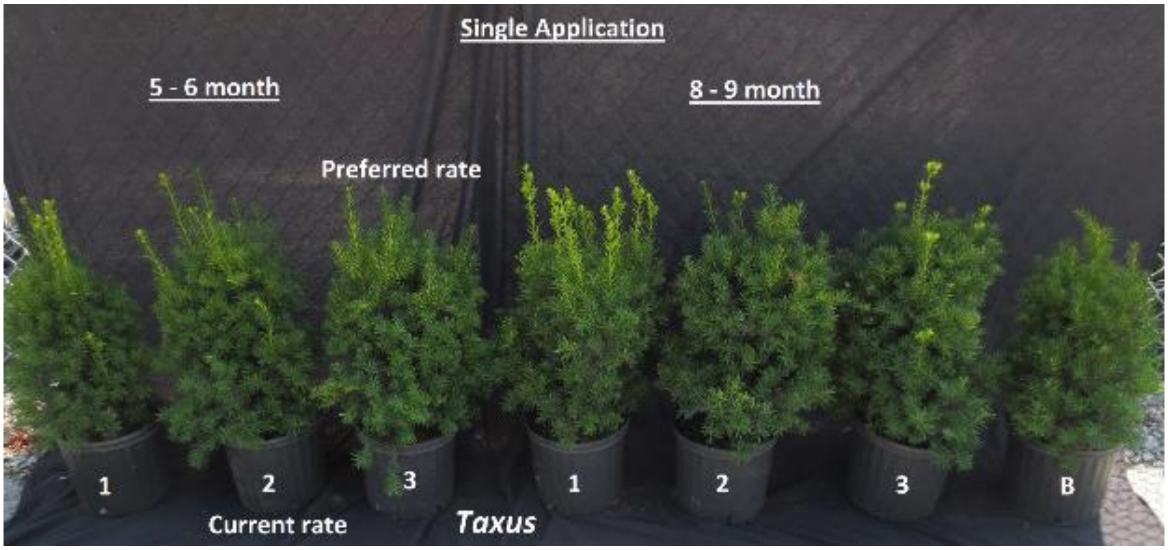
3 gal trial (2016-2017)

Topdressed, Single Application

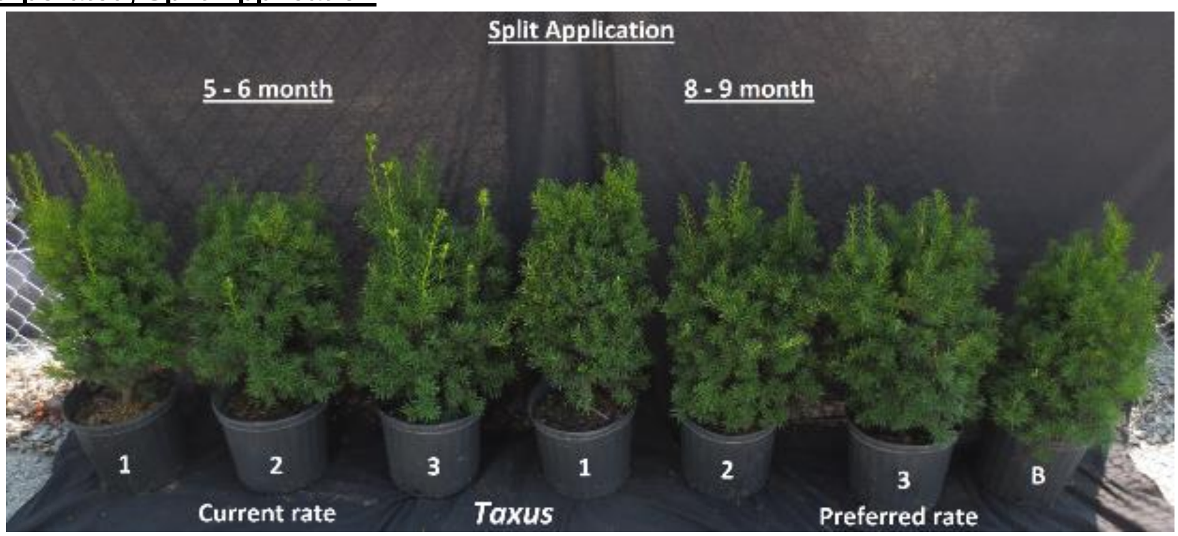
Topdressed, Split Application



Incorporated, Single Application



Incorporated, Split Application



Conclusions

The results of this study showed:

1) Application method (incorporated vs. topdressed) did not influence preferences of plant growth
2) For Green Velvet boxwood, split dose (applying a low initial CRF rate and later re-applying additional CRF) applications of CRF were preferred for 5-6 month duration CRF, while 8-9 month duration CRF was preferred for a single dose. Application rate of 1.40 $kg{\cdot}m^{-3}$ N was preferred, regardless of application method or duration.
3) For Hill's yew, an 8-9 month duration was preferred for split applications with either method, and a single application was preferred when topdressing. A 5-6 month duration was preferred for a single incorporated application. Application rate of 1.40 $kg{\cdot}m^{-3}$ N was preferred in all cases.
4) Container colour or adding additional potassium (K) did not result in any growth improvements for either Green Velvet boxwood or Hill's yew, compared to current practices.

Niagara Region: Vineland Research and Innovation Centre – Boxwood Propagation

Fertilizer: Plant Products 20-8-20 water soluble fertilizer applied at one of five rates (100, 150, 200, 250, and 300 ppm N), as needed.

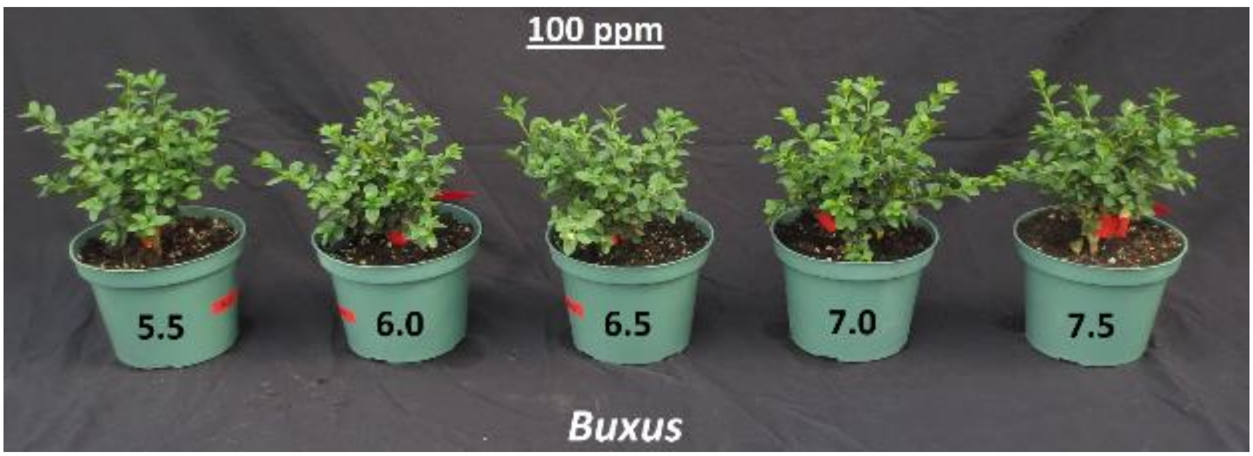
Growing Substrate: Berger custom blend 75:25 peat:perlite, with 1:0.9 dolomitic:calcitic limestone incorporated at rates of 8.4, 11.4, 16.0, 24.1, and 135.0 $g \cdot L^{-1}$ to achieve desired pH levels of 5.5, 6.0, 6.5, 7.0, and 7.5.

Trial Dates: June – December, 2016

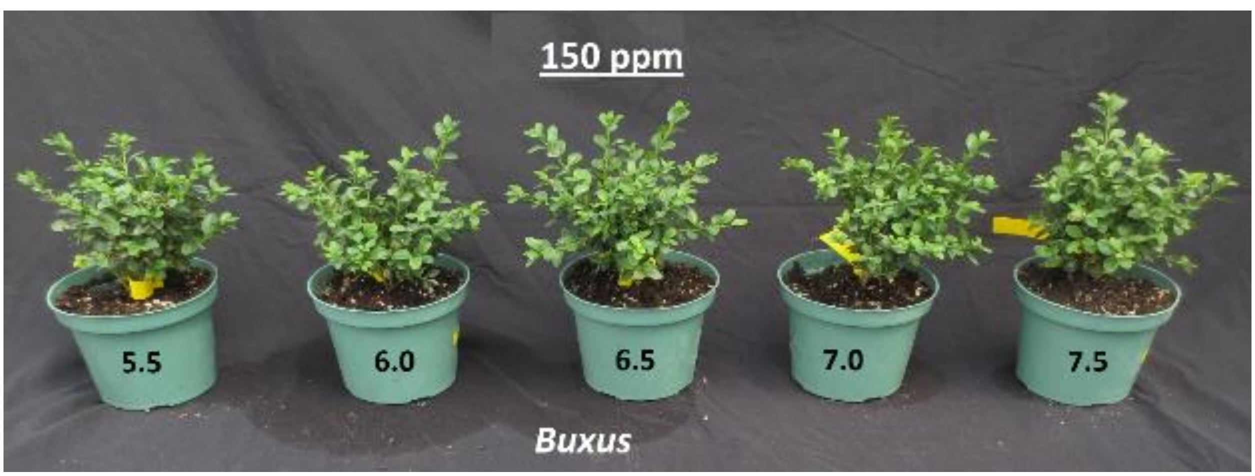
- **6-inch diameter containers grown in a greenhouse at 26-27°C, with 40-60% humidity**

The following are the growth performance results:

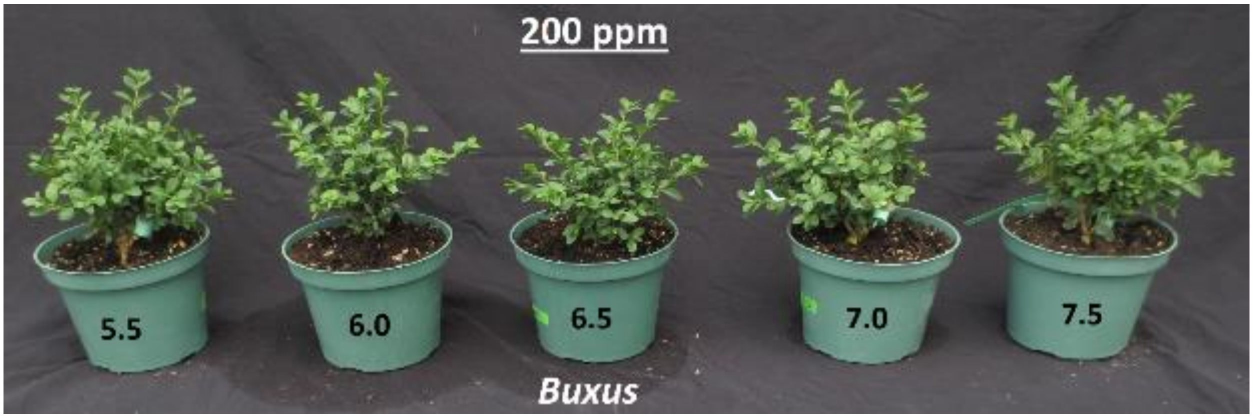
100 ppm N



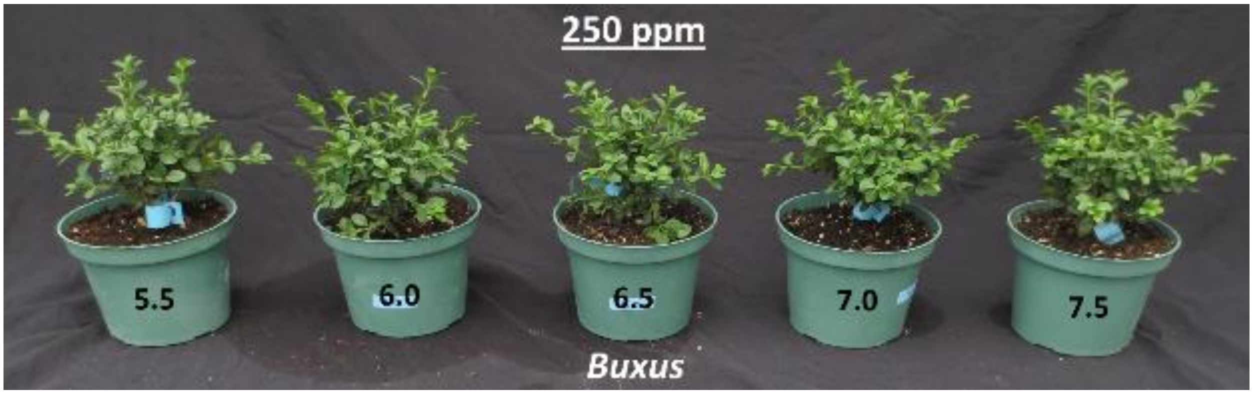
150 ppm N



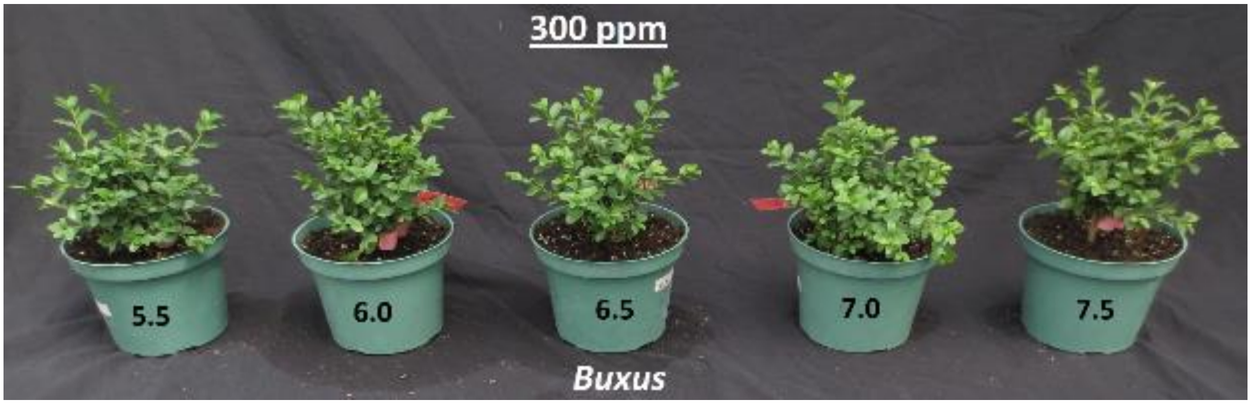
200 ppm N



250 ppm N



300 ppm N



Conclusions:

During this study neither pH nor fertilizer rate was able to accelerate growth of young boxwood liners in a propagation environment.

Young boxwood liners showed great adaptability to pH and fertilizer rate, as no negative effects of pH or fertilizer at any rate of the applied range was observed for boxwood during the study.

Niagara Region: Vineland Research and Innovation Centre

Fertilizer:

Conventional: Osmocote 15-9-12, 5-6 month. Applied at planting and again at the start of the second growing season (June 30, 2015 and June 8, 2016).

Organic Granular: Custom blend of 1:1.82 Bio-Fert General Purpose: Bio-Fert Blood Meal. A portion of the total rate was applied at three application times during 2015 and also in 2016.

Fertilizer rates topdressed:

Treatment :	1	2	3	4	5	Unit
	0.30	0.50	0.70	0.90	1.10	kg N·m^{-3}
	0.51	0.84	1.18	1.52	1.85	lb N·yd^{-3}
	3.40	5.60	7.87	10.13	12.33	lb fertilizer·yd^{-3}

Organic Liquid: Custom blend of 1:0.9 Bio-Fert 2.5-2-5 General Purpose liquid fertilizer: Bio-Fert CaO liquid fertilizer applied at rates of 12.2, 14.7, 18.6, 25.3, and 39.5 mmol·L^{-1} N. Fertilizer was applied at each watering event during the study.

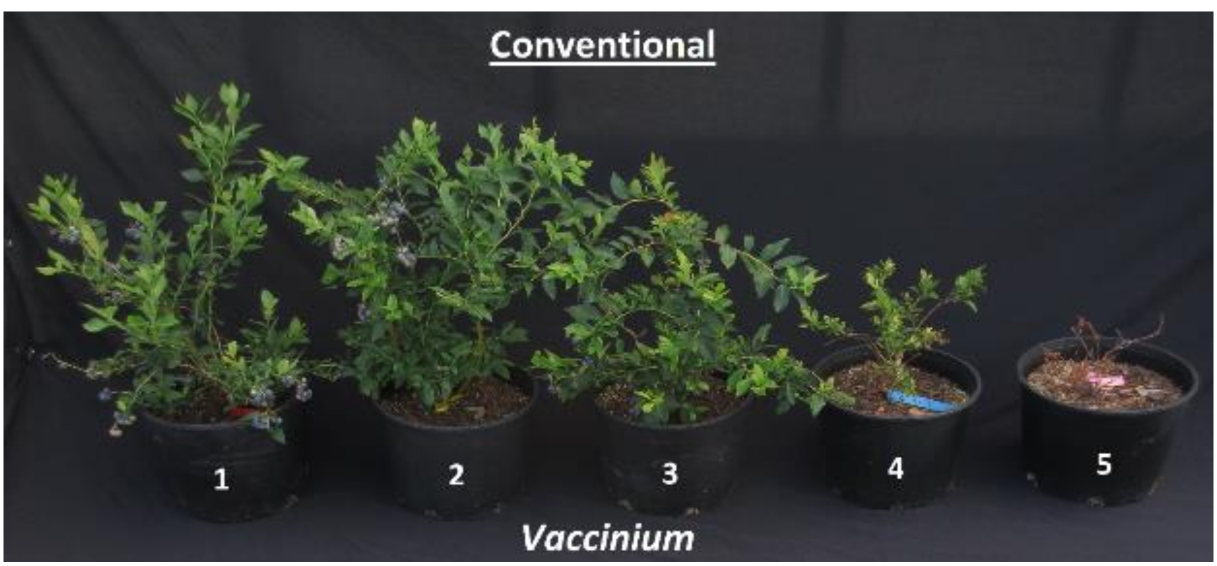
Growing Substrate: Conventional: composted pine mulch, coir, and peat; Organic: customized coir mix

Trial Dates:

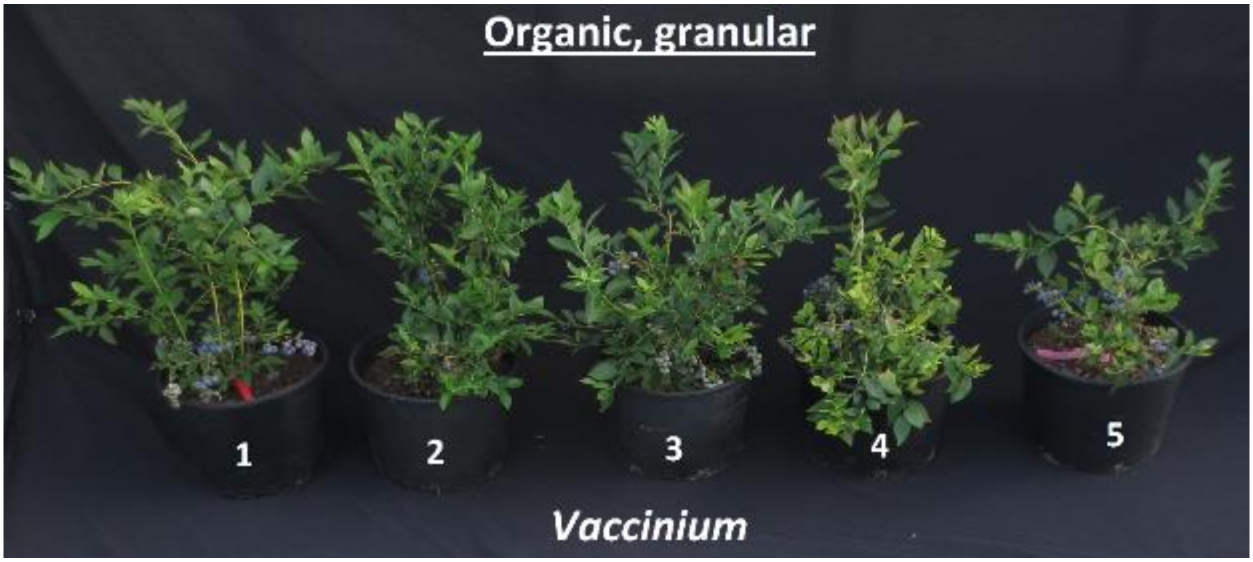
- 5-gal containers (June 2015 – Aug. 2016)

The following are the growth performance results:

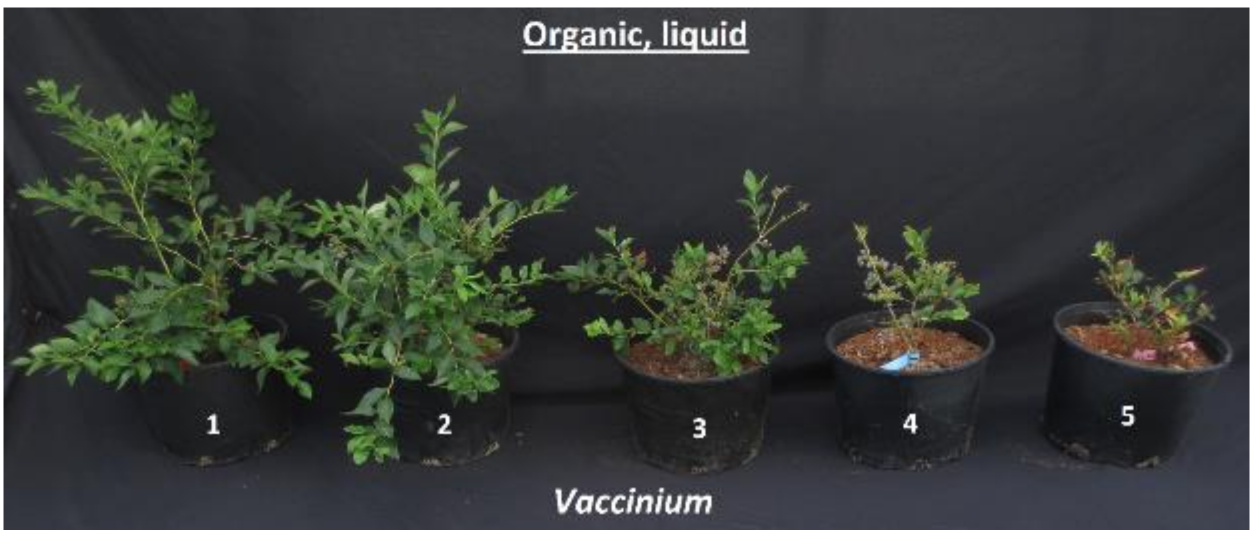
Conventional



Organic, Granular



Organic, Liquid



Niagara Region Nursery (Vineland)

Fertilizer: Blue Max; coated Aluminum Sulfate (14S, 13.8 Al)

Growing Substrate: Gro-Bark proprietary blend

Trial Dates: May - July, 2016
3-gal containers: *Hydrangea macrophylla* 'Endless Summer'
2-gal containers: *Hydrangea macrophylla* 'Paraplu'

The following are the flower colour results:

Fertilizer rates topdressed in second year of growth:
**Single dose indicates total amount applied in one application, split dose indicates half of the total amount applied at each of two separate applications.*

Treatment :	1	2	3	4	5	6	Unit
	0.00	3.6	4.8	5.9	7.0	8.1	$g \cdot L^{-1}$

***Hydrangea macrophylla* 'Endless Summer', Single Dose* (May, 2016)**

***Hydrangea macrophylla* 'Endless Summer', Split Dose (May and June, 2016)**

Hydrangea macrophylla **'Paraplu', Single Dose (May, 2016)**

Hydrangea macrophylla **'Paraplu', Split Dose (May and June, 2016)**

Influence of Storage on Nursery Growing Substrates and Consumer Potting Mixes with Incorporated Controlled-Release Fertilizer

Based on our research, we observed that once the temperature of the bark-based nursery growing substrate was above 30 °C, nutrients began to release from the controlled-release fertilizer (CRF), regardless of coating formulation. Therefore, storing bark-based growing substrates containing CRF is not recommended, especially if nursery crops are sensitive to high soluble salt content (e.g., EC levels > 1.5 $mS \cdot cm^{-1}$). If high soluble salt content occurs, nursery growers can flush the growing substrate with clean water, prior to potting, to reduce the salt content and collect the runoff water to prevent leaching into the environment.

During another study, we observed that nutrient release began 24 hours after incorporation of CRF into a bark-based nursery growing substrate, regardless of storage location or product longevity. Nutrient release continued to increase after the 24 hour time point had been reached. We observed the substrate EC increasing during 10 days of storage at a daily average temperature of 24 °C (Figure 1), which is comparable to the typical air temperature during early summer in Ontario, Canada. Therefore, storing a bark-based nursery substrate with incorporated CRF for 10 days will likely raise EC levels, but these levels are not high enough to damage actively growing species requiring medium to moderate nutrient levels (e.g., 1.5–3.5 $mS \cdot cm^{-1}$). However, growers should keep in mind that the longer the CRF-containing substrate stays in storage the more likely it will accumulate soluble salts reaching higher EC levels.

Consumer potting mix containing Polyon® 10-12 month CRF, stored for six months outdoors during summer, fall and winter months, did not increase in EC or pH to unacceptable levels. Therefore, retailers should not be concerned about selling consumer potting mix products from previous years, since products are likely to contain adequate levels of nutrients for plant growth.

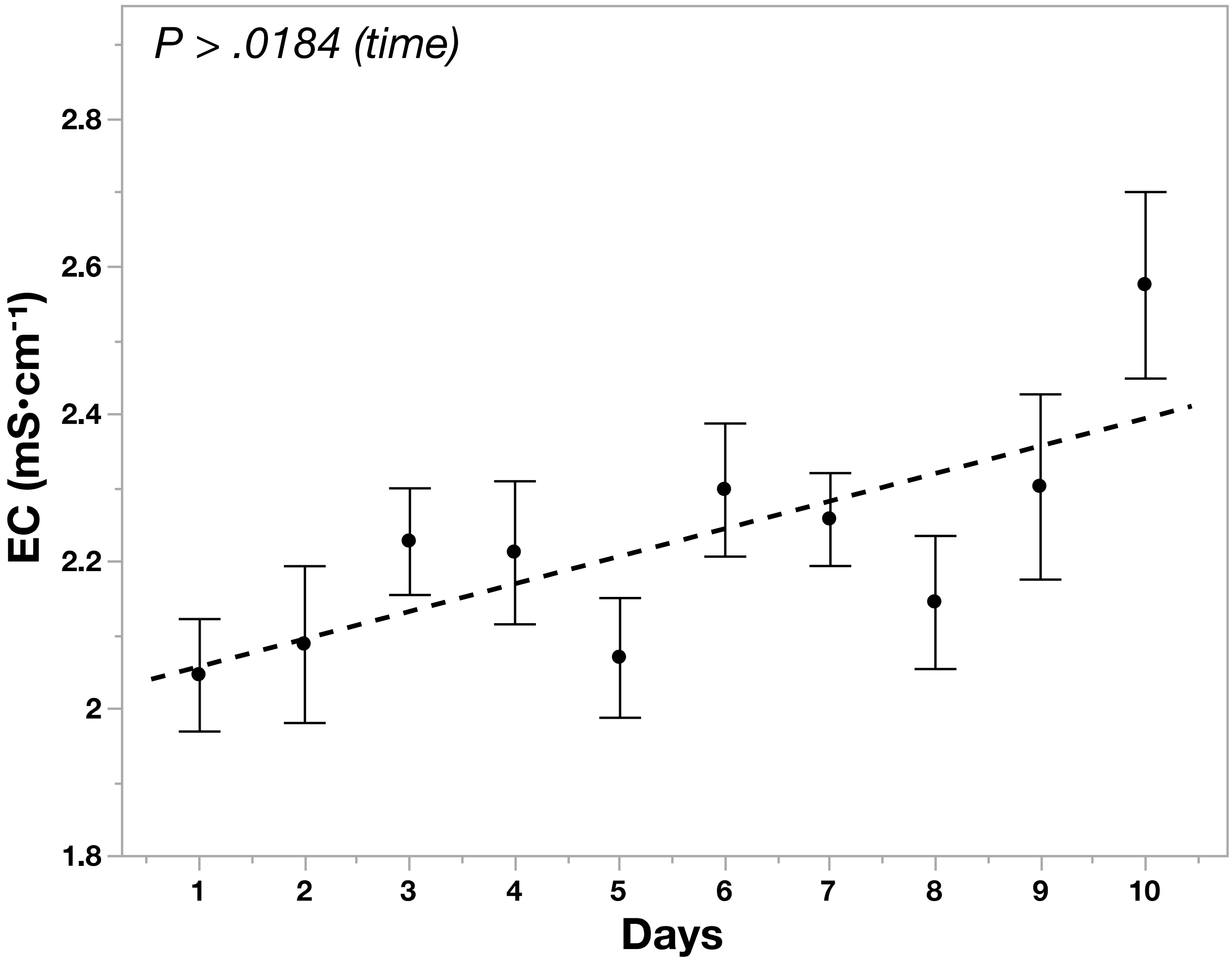


Figure 1. Electrical conductivity of a bark-based substrate over time following incorporation of a controlled-release fertilizer.