



Nursery Drought Conditioning and Genetic Effects of Douglas-fir Seedlings Growing in Three Sites in Western Oregon

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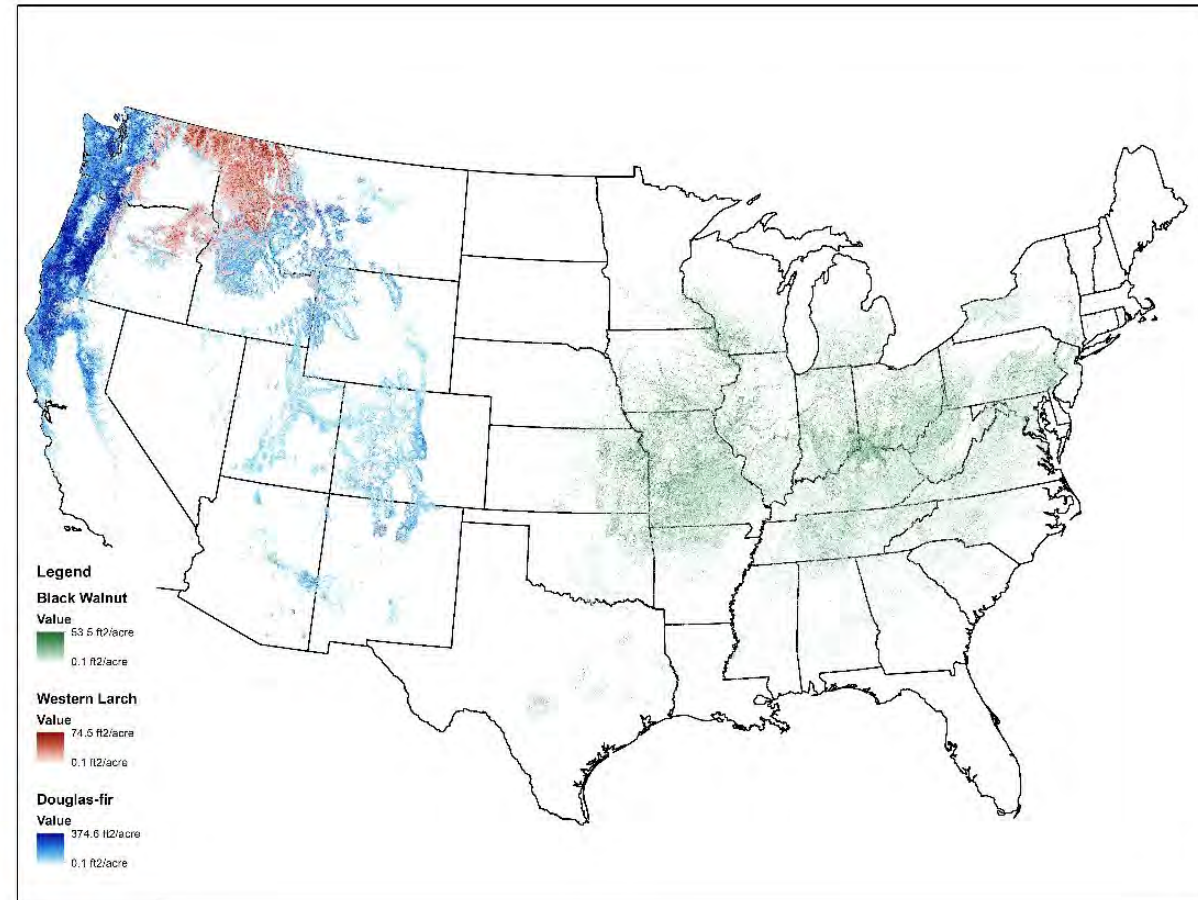
Objective

To examine seedling physiology and root system architecture in response to nursery-induced drought conditioning intensity and subsequent drought.

These factors will be examined across three commercially important tree species in the United States (coastal Douglas-fir, western larch, and black walnut) and for seed sources from different maternal tree environments.

This presentation focus on Douglas-fir.

US Species Distributions



Source: Wilson et al. 2013. Live tree species basal area of the contiguous US (2000-2009). USDA Forest Service. <https://www.fs.usda.gov/rds/archive/catalog/RDS-2013-0013>

Inland: 074 (Starker Forests). Medium gain **inland** seed source. Open pollinated at Schroeder Seed Orchard. Styro 20

Coastal: 075 (Starker Forests). Mix of 4 medium gain **coastal** seed sources. Open pollinated at Schroeder Seed Orchard. Styro 20

Cascade Foothills: 185 (Cascade Timber Consulting). Cottage Grove Blend 09. Styro 15

June 2020: Transportation of seedlings to UI



Grown at PRT Nurseries

Hubbard : Starker

Cottage Grove: CTC

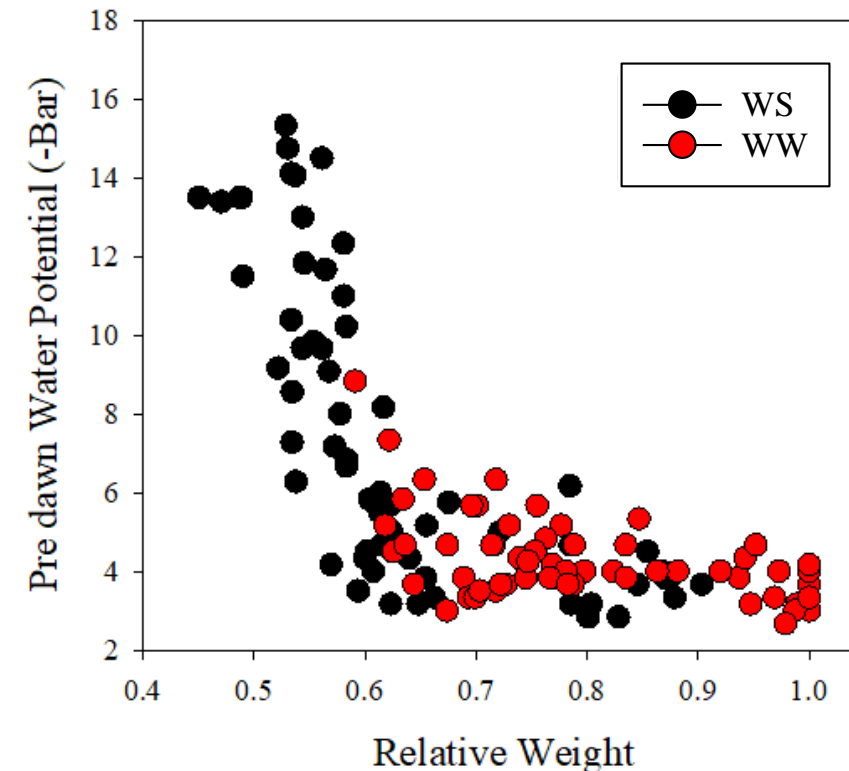
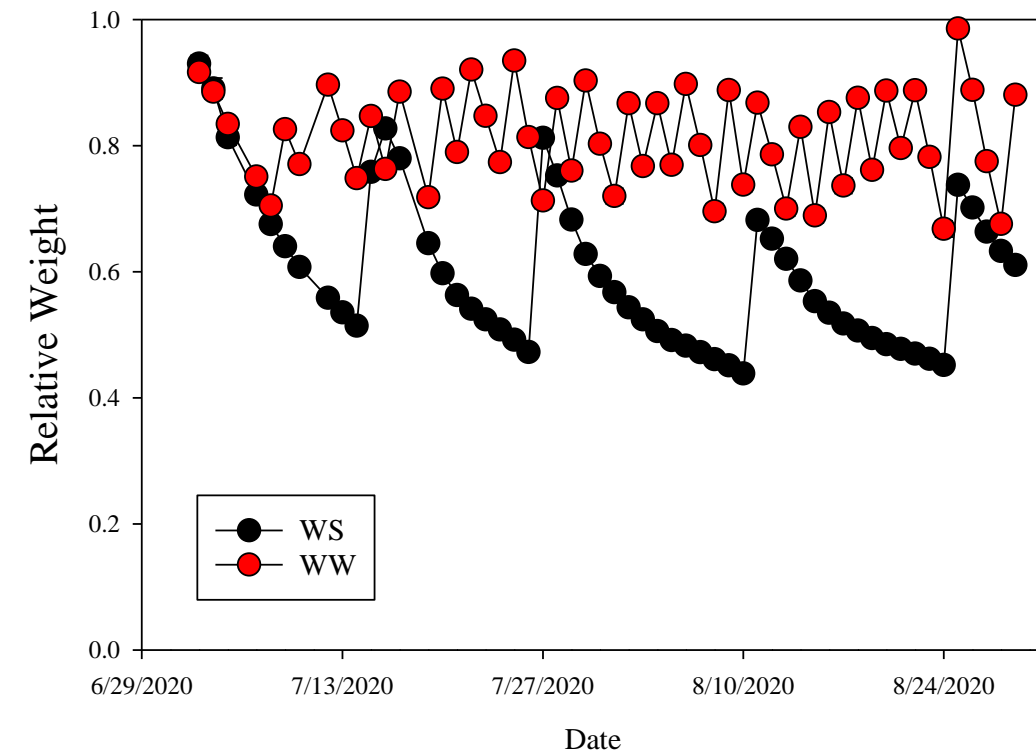
Sown in 02/2020

Transported to IU on 06/12/2020

Watering treatments

The drought conditioning treatments were

- (1) **Control**, no water stress: allowed moisture to decrease to 70% of saturated before watering to saturation,
- (2) **Moderate** water stress: dried down to 60% of saturated weight
- (3) **Extreme** water stress: dried down to 50% of saturated weight



Methods

Watering Treatments

The exact watering prescriptions differed by species due to differences in physiological responses to water limitations and minimizing the chances of seedling mortality.

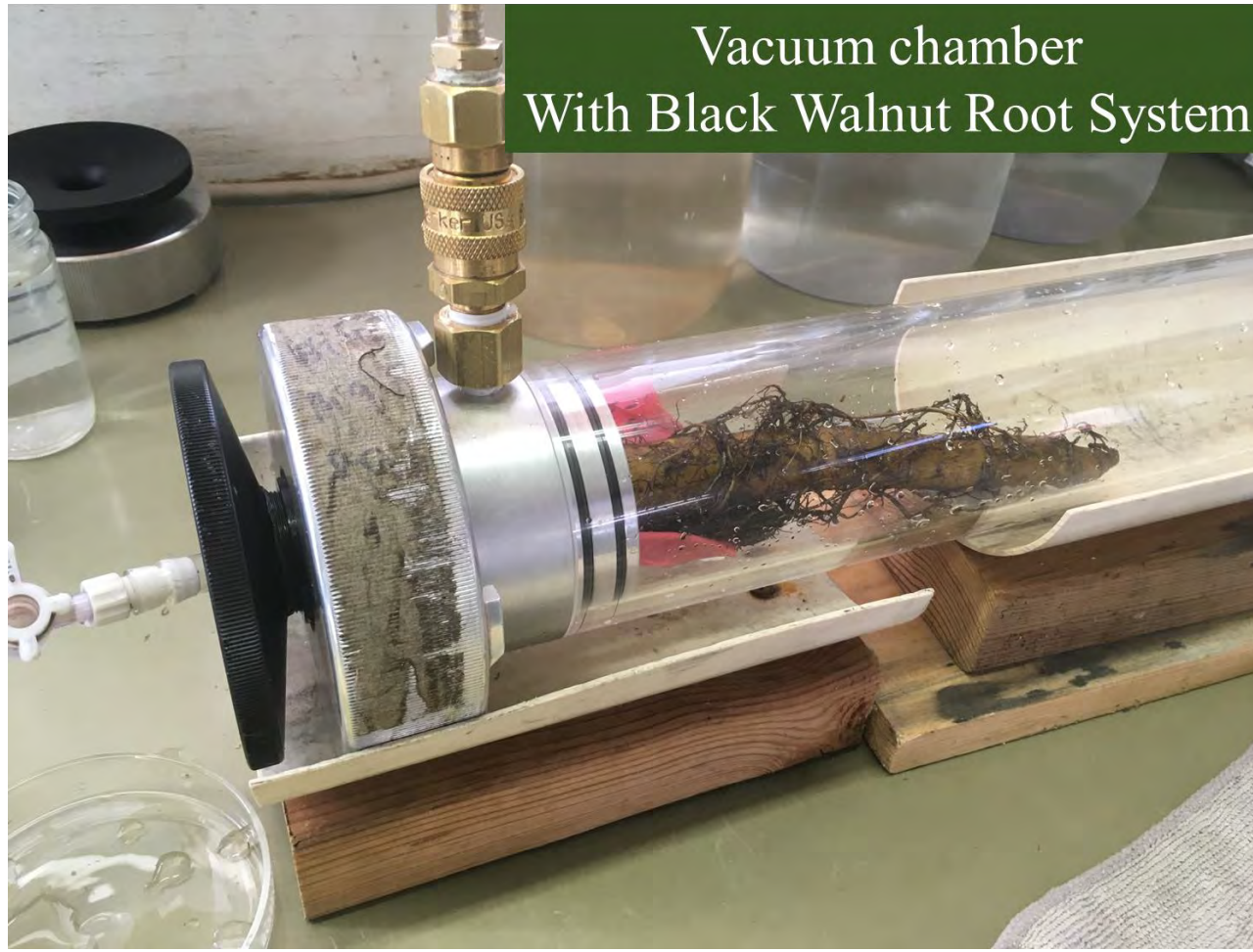
Light was provided by natural light and supplemental lighting. Watering treatments were applied at each watering event. The experiment was conducted in 2020.



Methods

Root Hydraulic Conductance

Root Hydraulic Conductance Apparatus
Vacuum chambers
Balance + PC



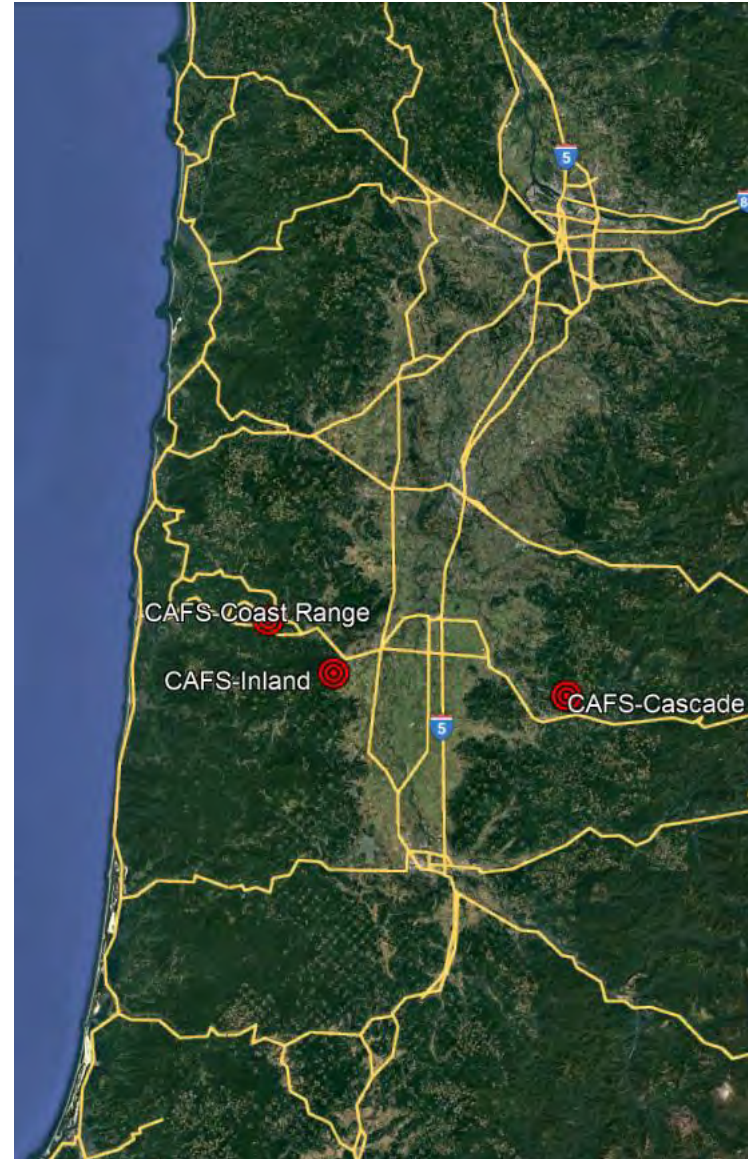
Vacuum chamber
With Black Walnut Root System



Seedling dry mass (leaves, stem, roots)

Also root and shoot volume (water displacement) and root morphology (WinRhizo)

3 Sites



Coast Range



Cascade Foothills



Inland



Planting Date:
02/16: Inland
02/18: Coast
02/23: Cascade

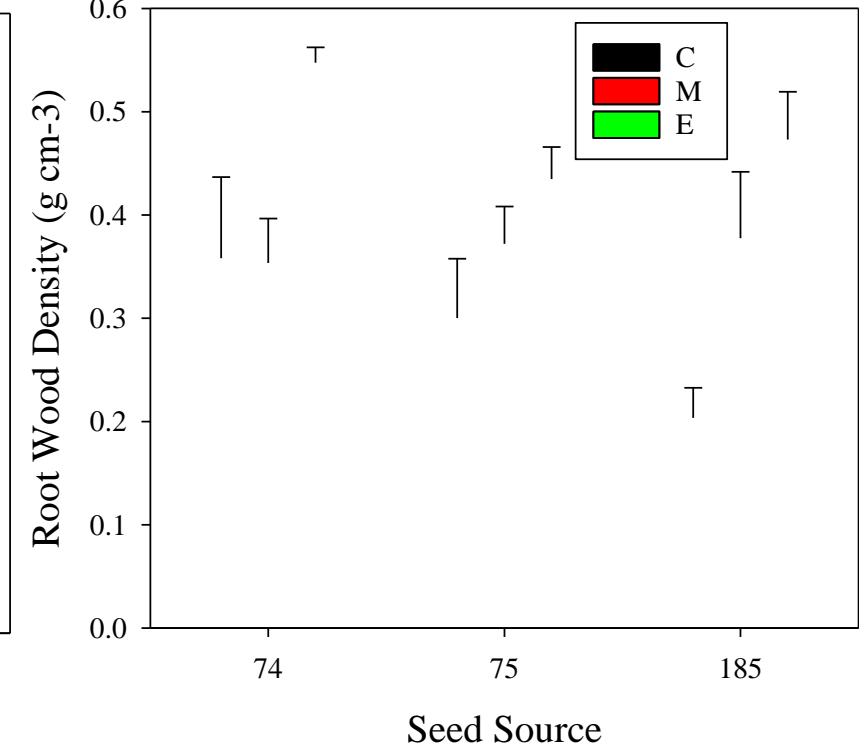
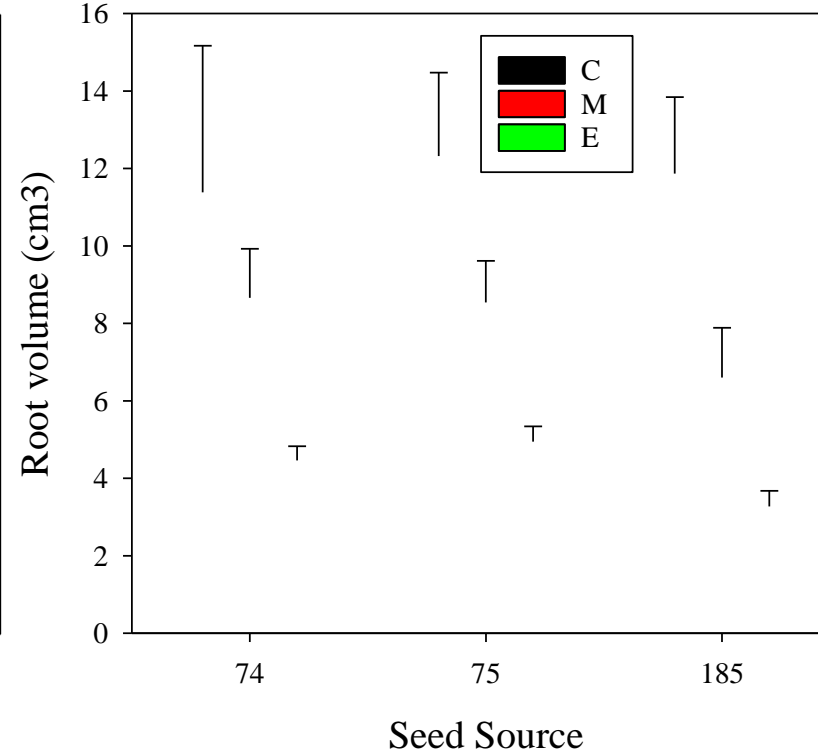
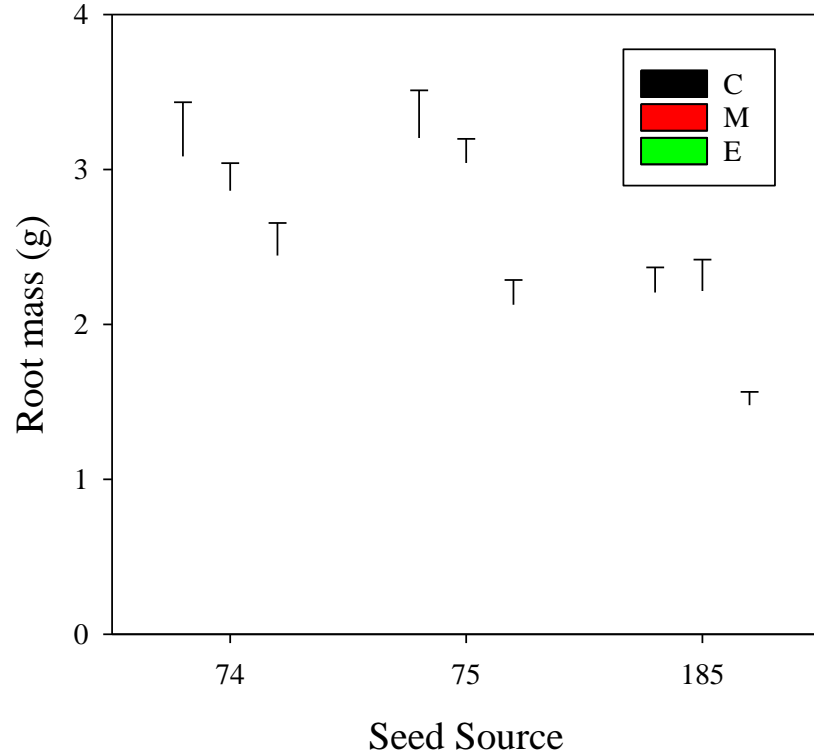
Results

Root Mass, Volume and Density

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Prov	2	8.20875529	4.10437764	17.79	<.0001
Trt	2	6.93180304	3.46590152	14.96	<.0001
Prov*Trt	4	0.52671130	0.13167783	0.57	0.6868

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Prov	2	21.69062973	10.84531487	52.71	<.0001
Trt	2	15.82158311	7.91079156	38.41	<.0001
Prov*Trt	4	1.32666020	0.33166505	1.61	0.1881

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Prov	2	0.34041662	0.17020831	27.71	<.0001
Trt	2	0.03988176	0.01994088	3.25	0.0481
Prov*Trt	4	0.02055555	0.00513889	0.84	0.5088



**At End of Nursery Watering Treatments
September**

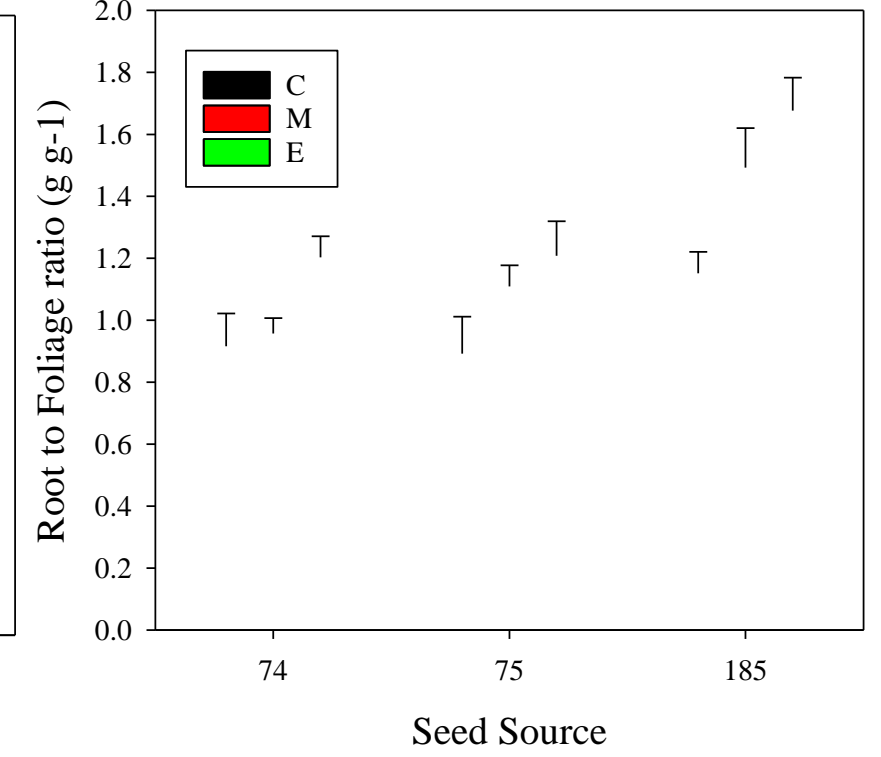
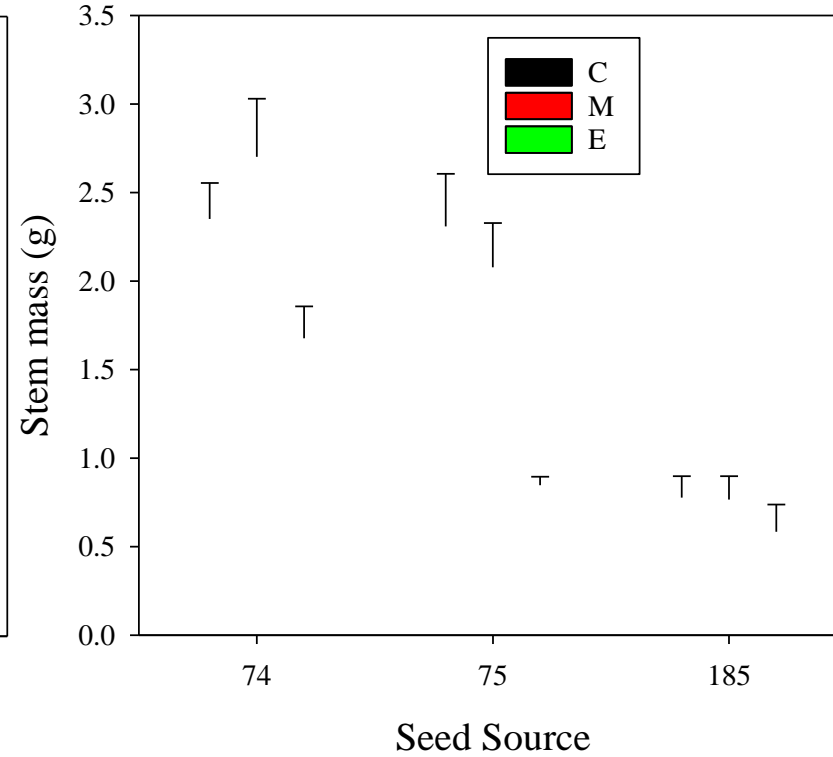
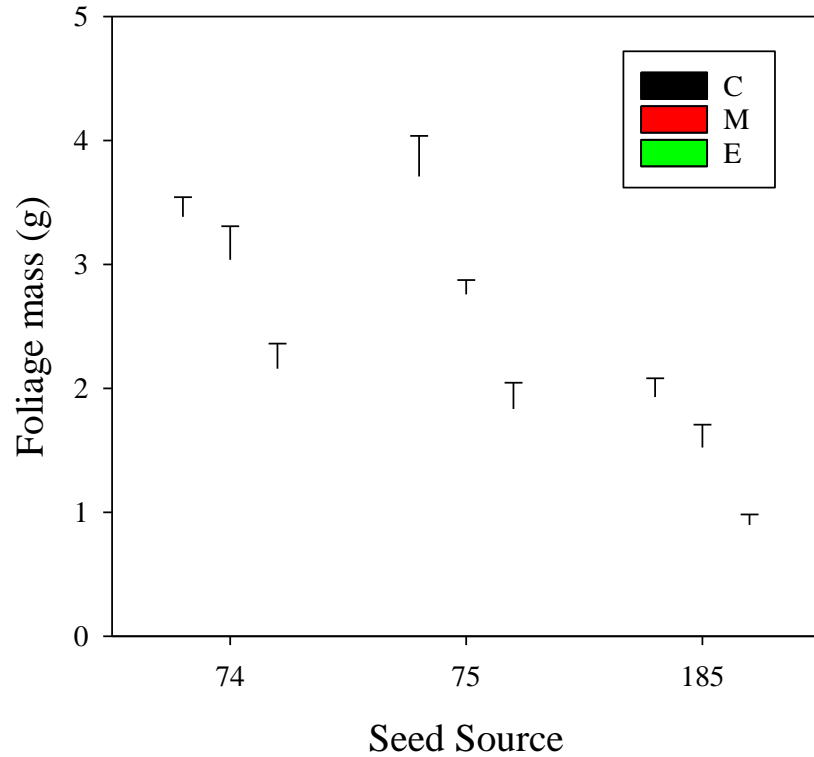
Results

Foliage, Stem and Root:Foliage

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Prov	2	21.69062973	10.84531487	52.77	<.0001
Trt	2	15.82158311	7.91079156	38.47	<.0001
Prov*Trt	4	1.32666020	0.33166505	1.61	0.1881

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Prov	2	20.81092519	10.40546259	47.43	<.0001
Trt	2	6.82642435	3.41321218	15.56	<.0001
Prov*Trt	4	3.21975333	0.80493833	3.67	0.0117

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Prov	2	1.80518146	0.90259073	19.41	<.0001
Trt	2	1.18316977	0.59158489	12.72	<.0001
Prov*Trt	4	0.18071708	0.04517927	0.97	0.4329

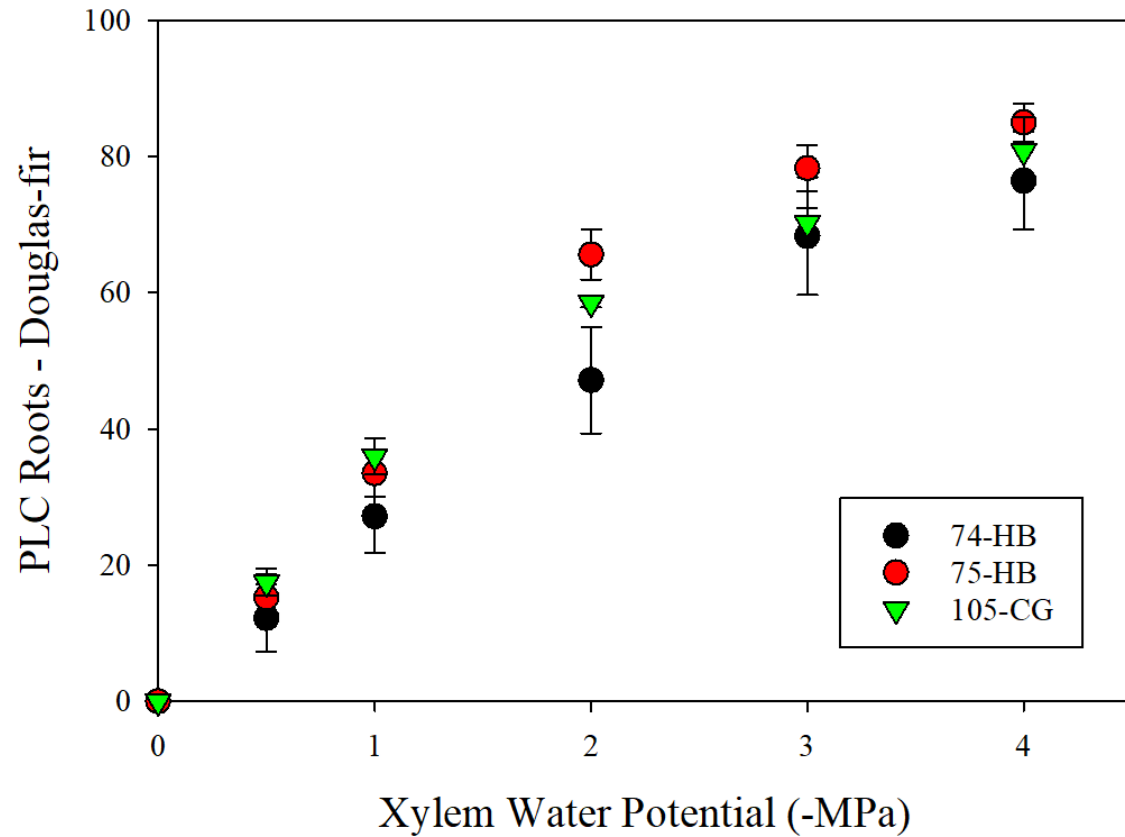


**At End of Nursery Watering Treatments
September**

Results

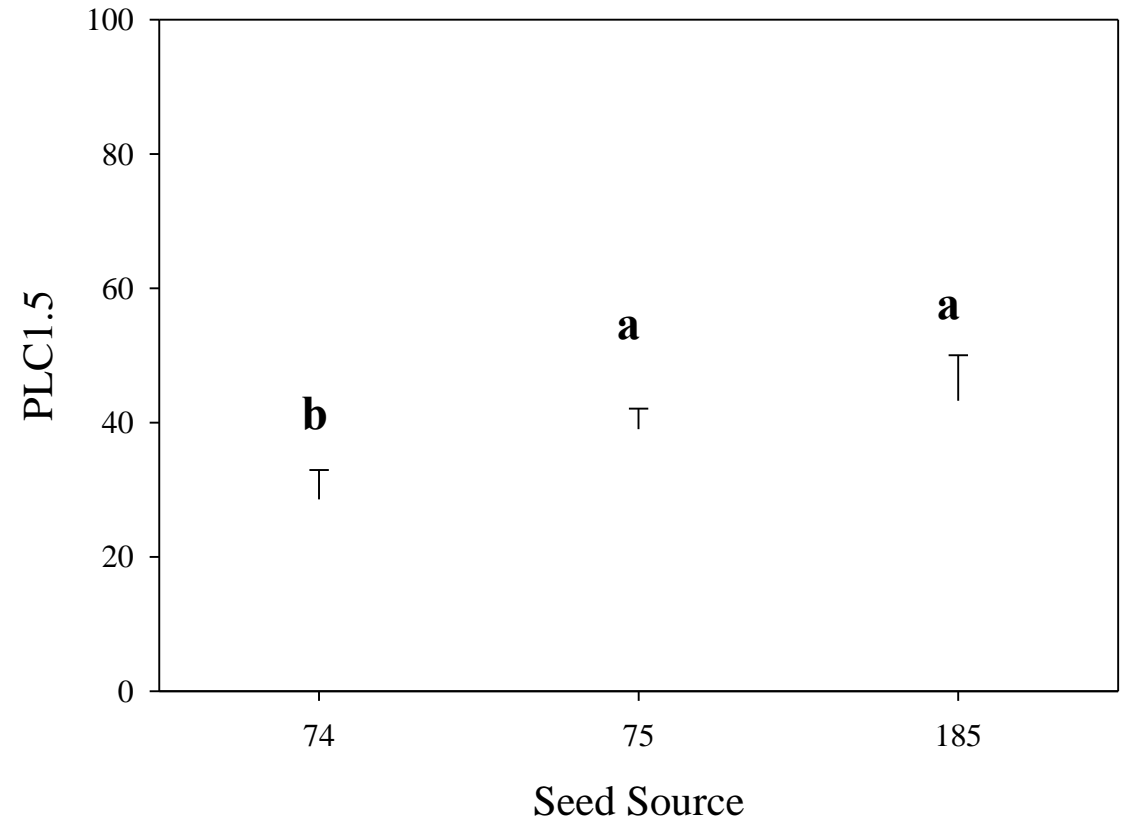
Root Hydraulic Conductivity

Vulnerability to Cavitation Curve



At beginning of nursery stage

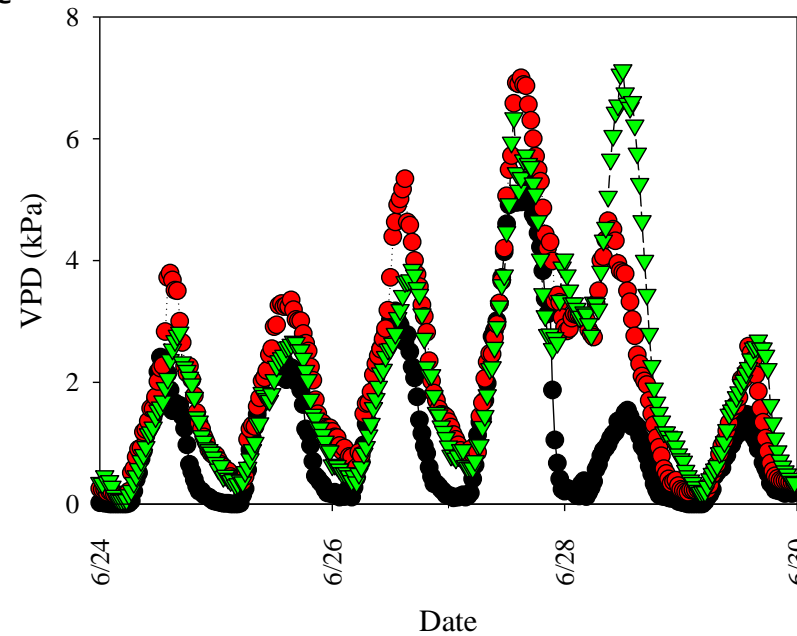
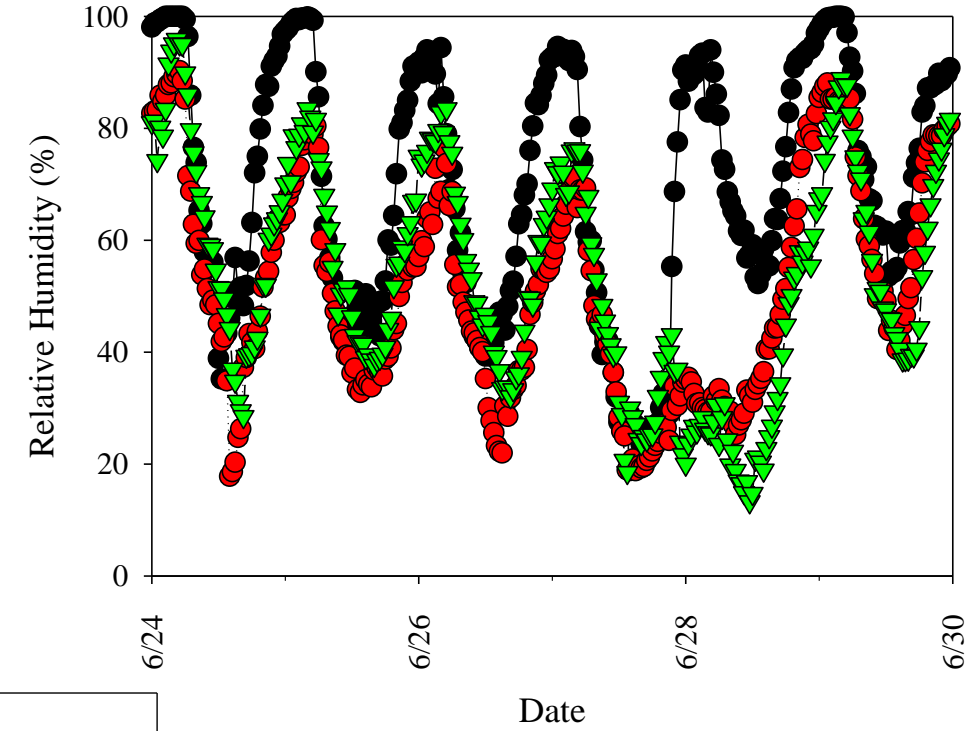
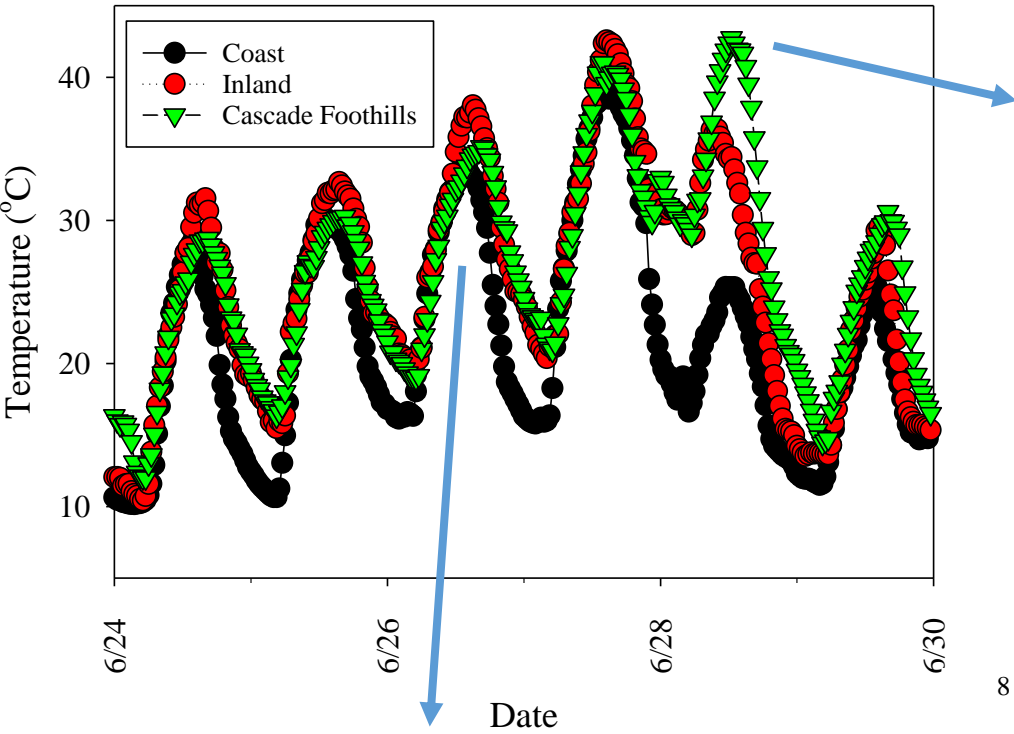
Percent Loss of Hydraulic Conductivity at 1.5 MPa (Control Treatment)



At end of hardening stage

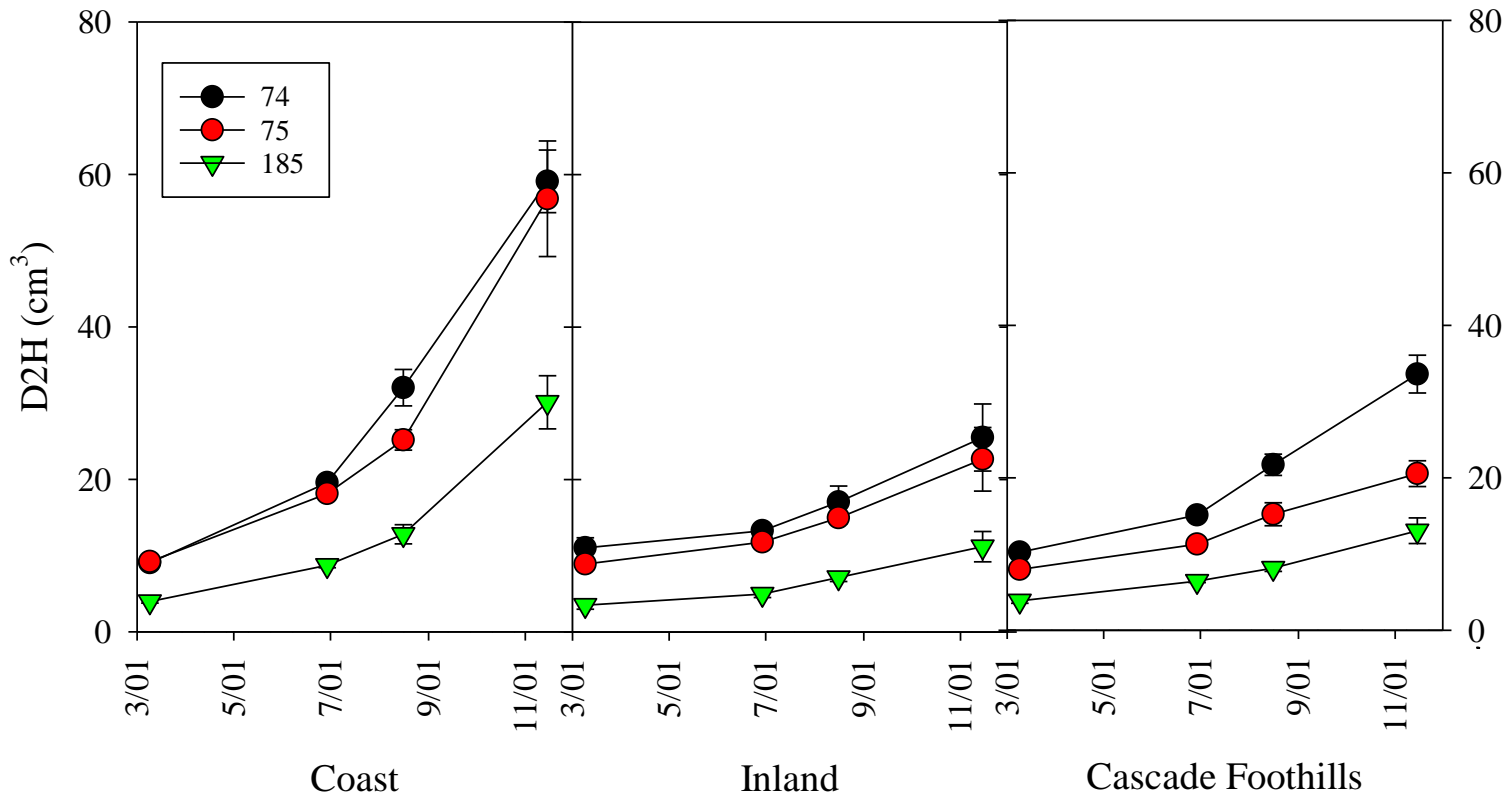
Results

Weather

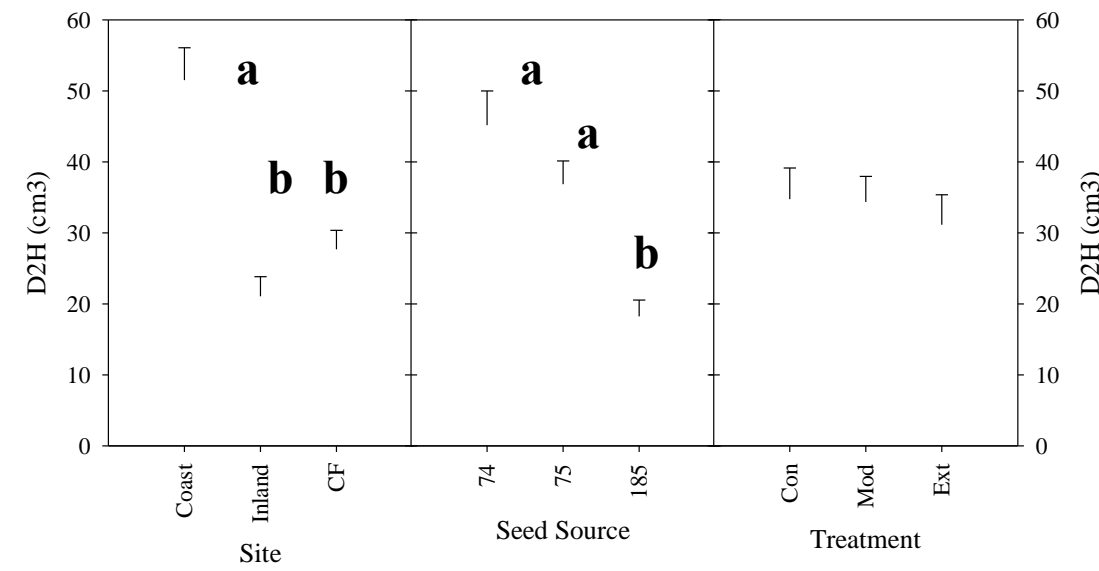


Results

Growth

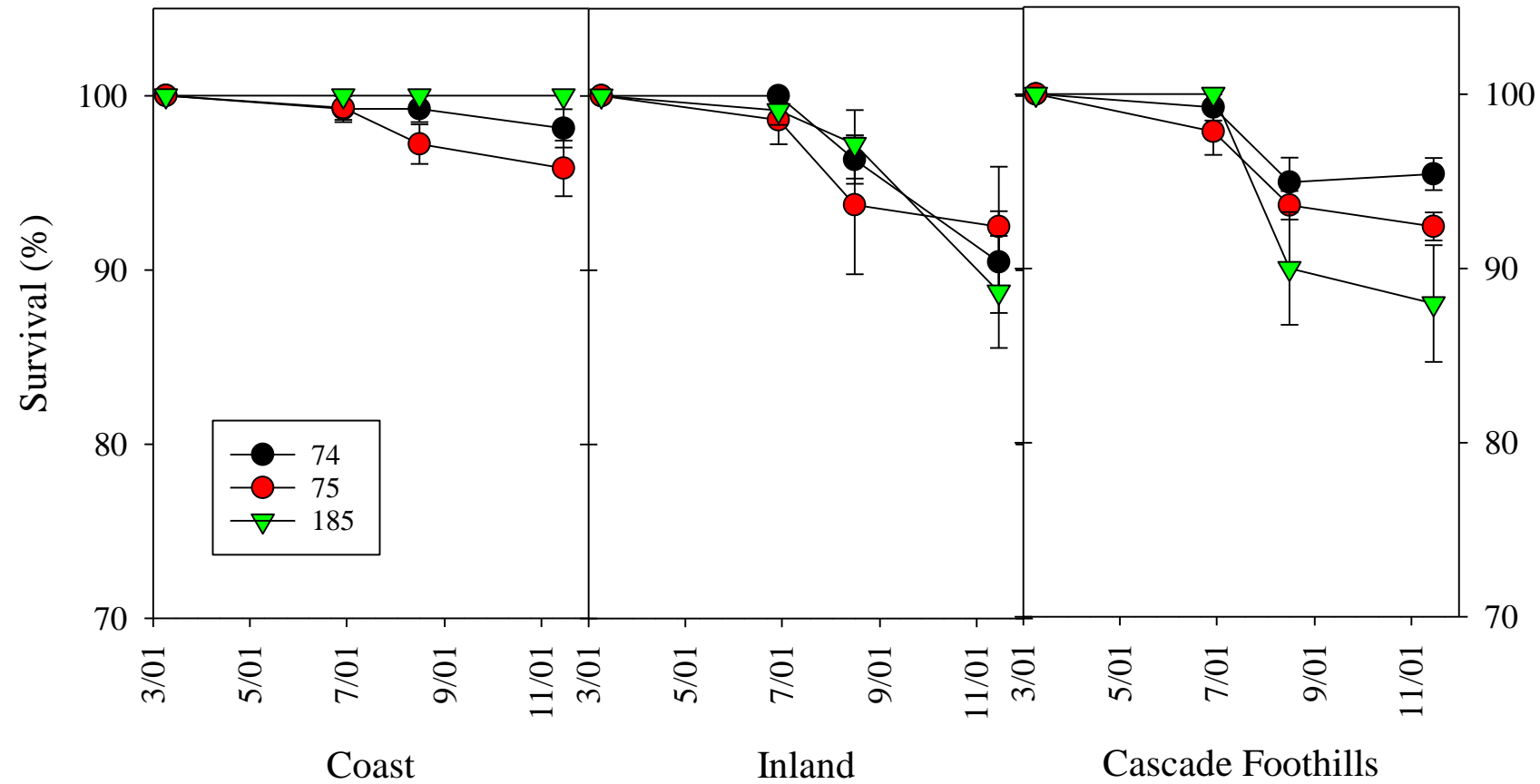


Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	78	11.94	<.0001
SS	2	78	13.06	<.0001
Trt	2	78	0.16	0.8555
Site*SS	4	78	0.59	0.6739
Site*Trt	4	78	0.76	0.5576
SS*Trt	4	78	0.37	0.8325
Site*SS*Trt	8	78	0.67	0.7171



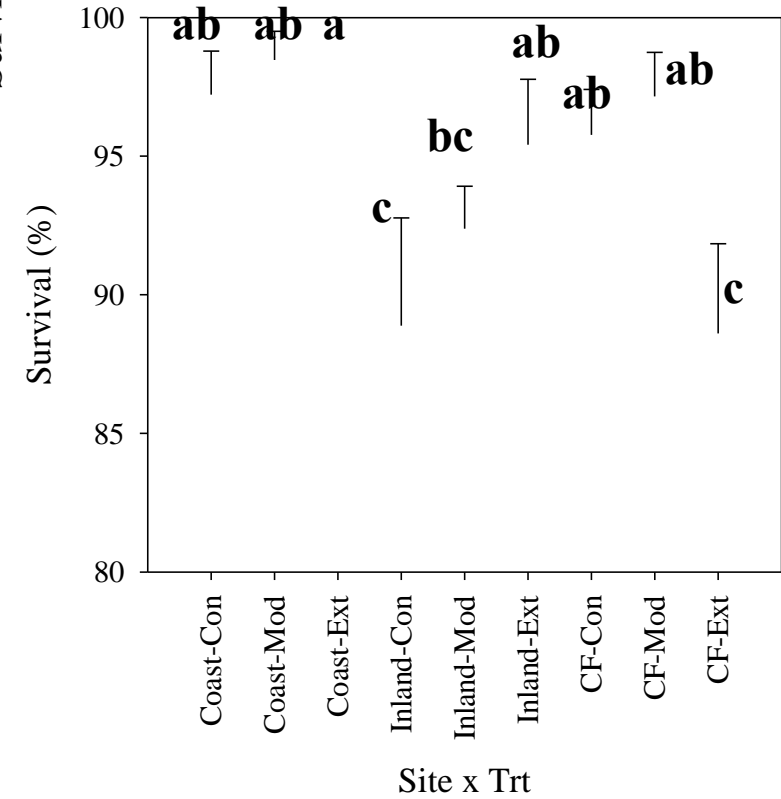
Results

Survival



Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	78	6.67	0.0021
SS	2	78	0.57	0.5678
Trt	2	78	0.70	0.4985
Site*SS	4	78	1.45	0.2245
Site*Trt	4	78	3.1	0.0185
SS*Trt	4	78	0.73	0.5728
Site*SS*Trt	8	78	1.00	0.4400

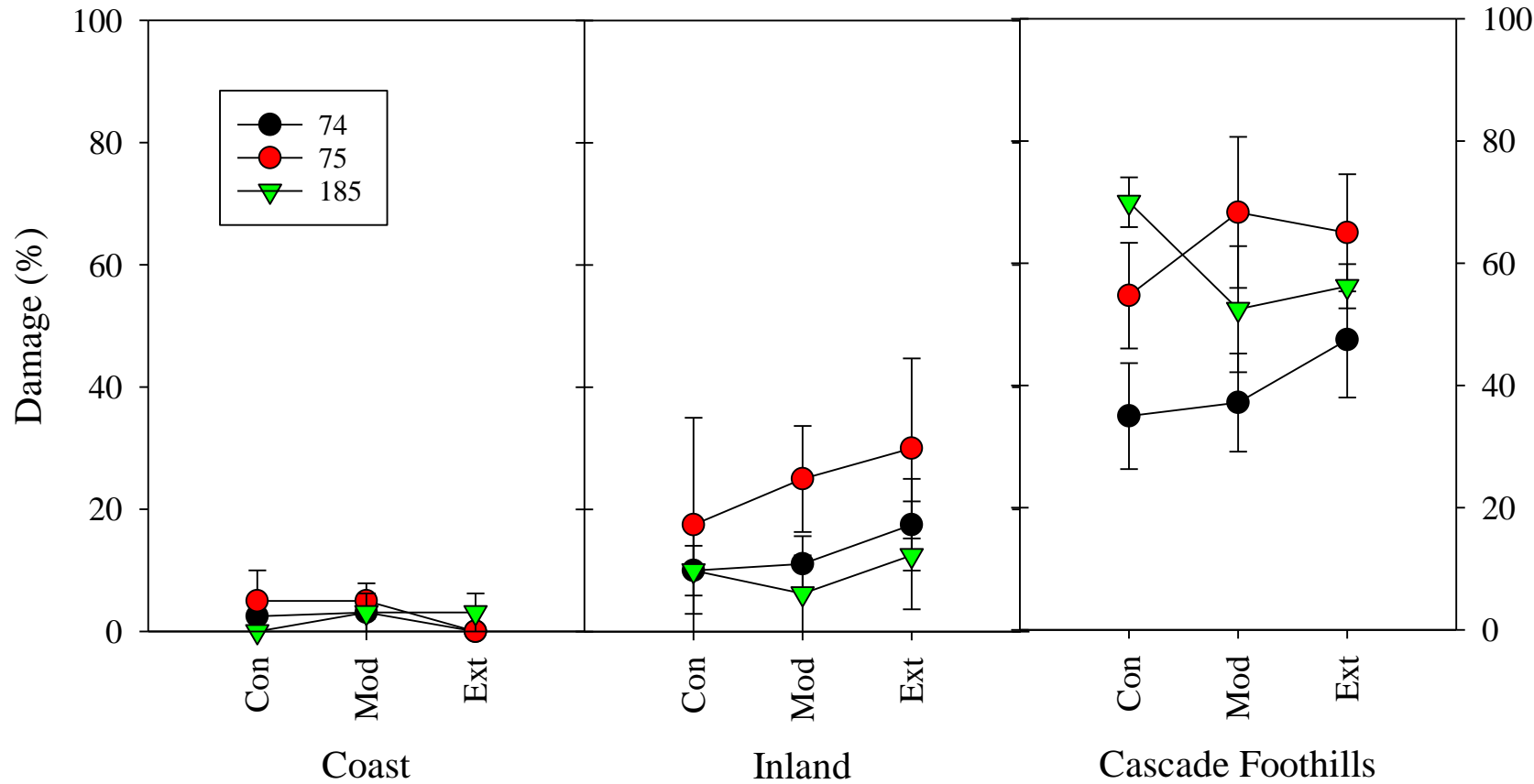
Survival (%)



Site x Trt

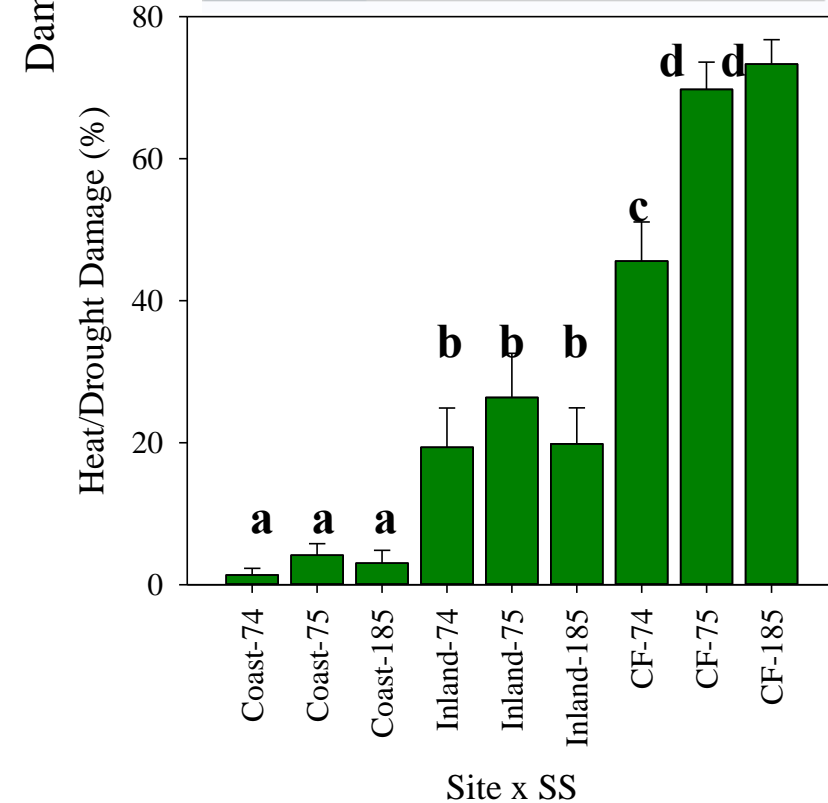
Results

Heat/Drought Damage

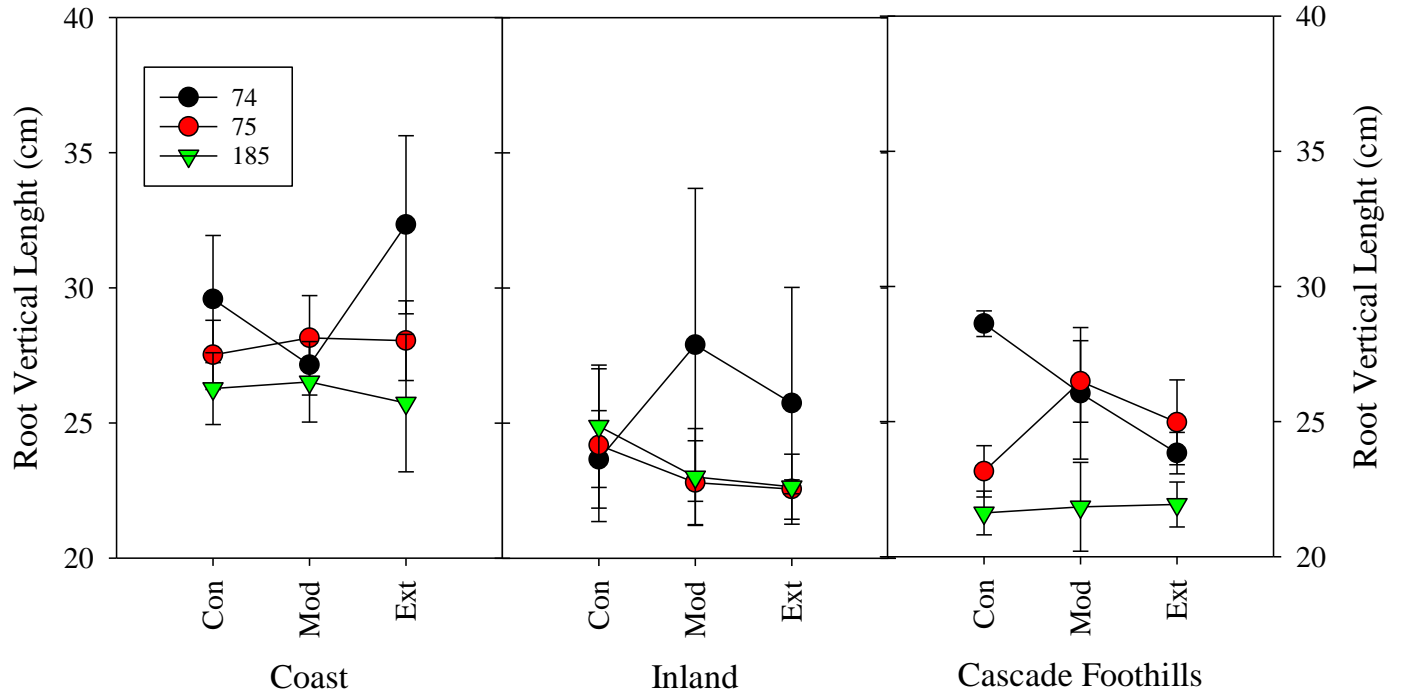


**End of Summer of First Growing Season
August**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	81	147.06	<.0001
SS	2	81	5.97	0.0038
Trt	2	81	0.94	0.3935
Site*SS	4	81	3.4	0.0127
Site*Trt	4	81	0.49	0.7457
SS*Trt	4	81	0.11	0.9804
Site*SS*Trt	8	81	0.71	0.6789



Root Vertical Length (cm)



**End of Summer of First Growing Season
August**

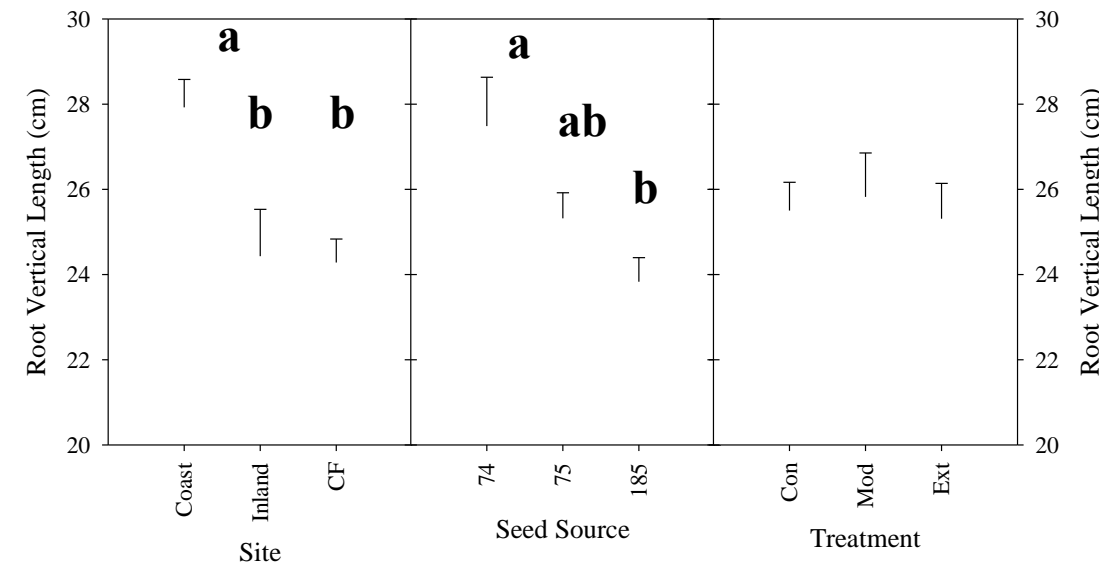


Coast – 74 - Mod

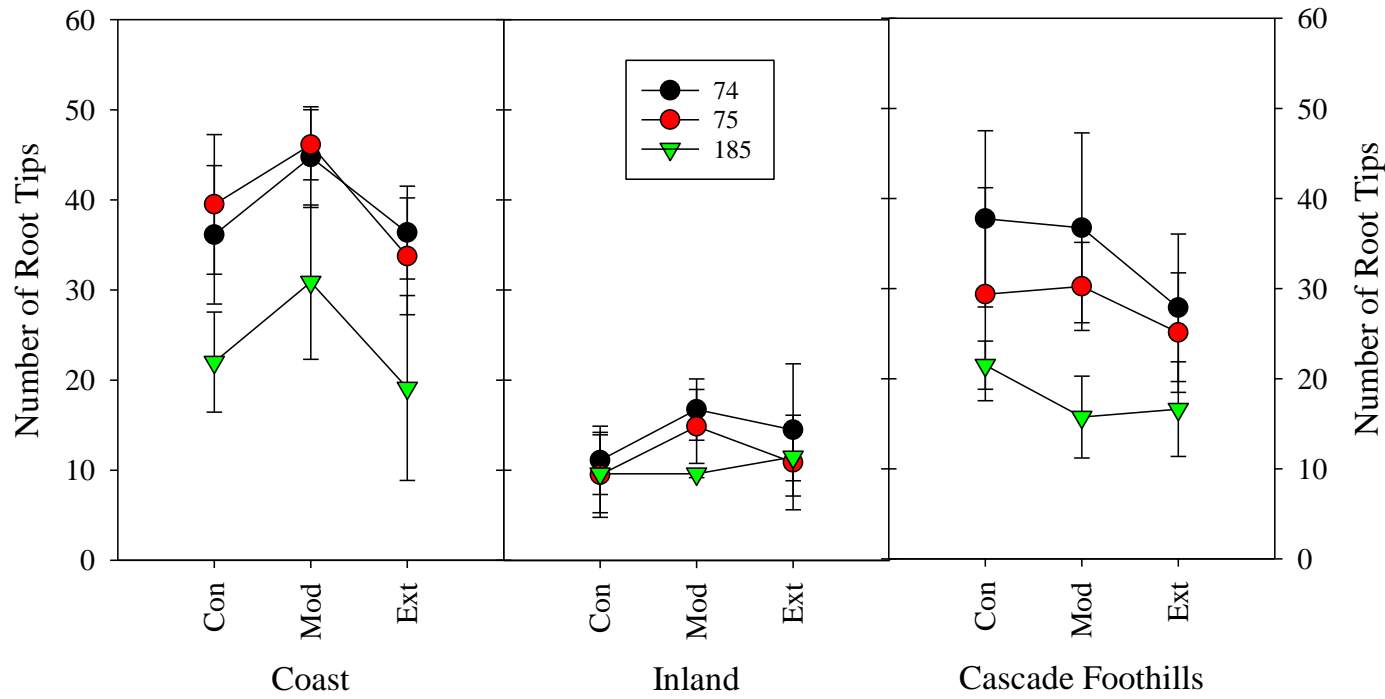


Inland – 185 - Mod

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	78	6.22	0.0022
SS	2	78	5.26	0.0072
Trt	2	78	0.10	0.9015
Site*SS	4	78	0.40	0.8096
Site*Trt	4	78	0.39	0.8129
SS*Trt	4	78	0.07	0.9908
Site*SS*Trt	8	78	1.03	0.4245

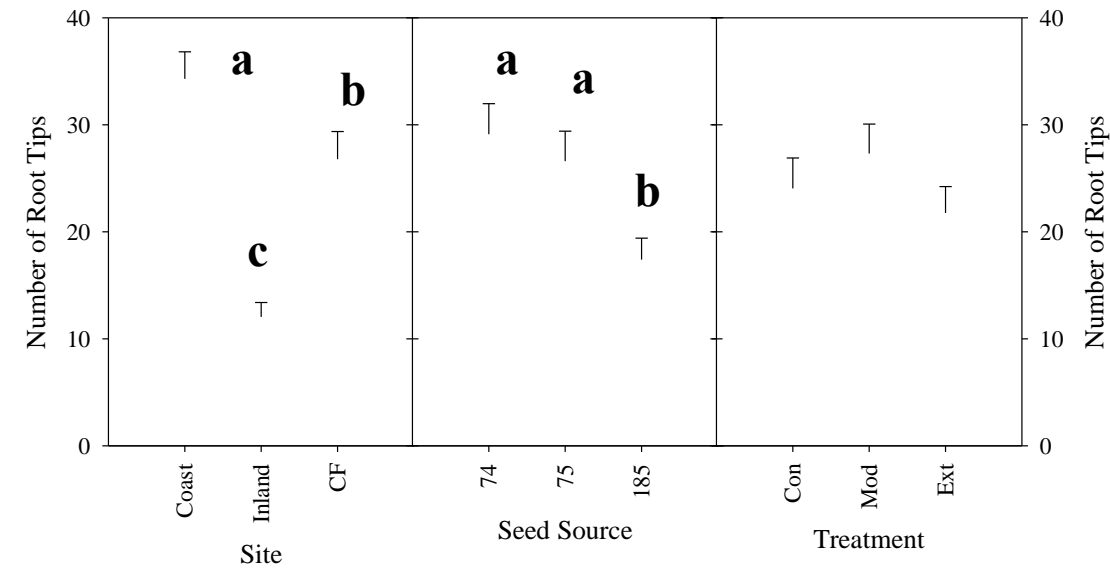


Number of New Root Tips

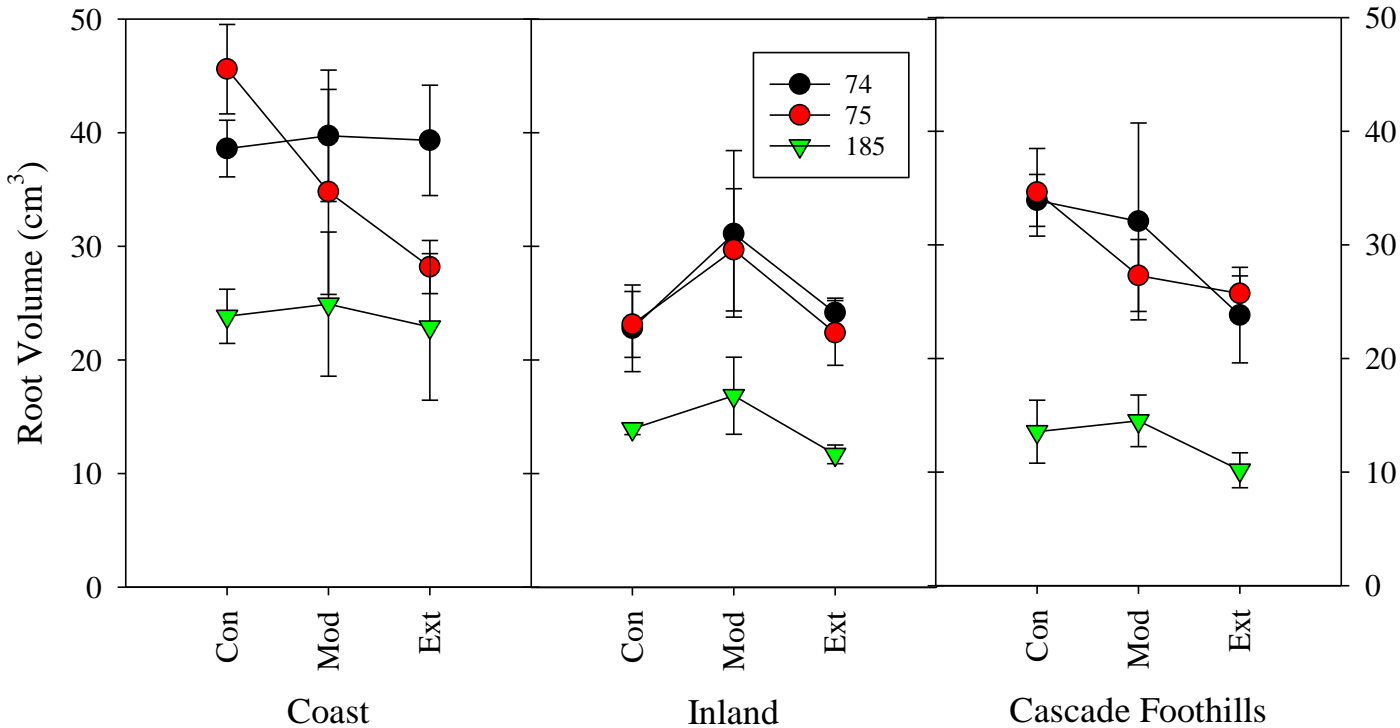


End of Summer of First Growing Season
August

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	81	27.0	<.0001
SS	2	81	8.0	0.0007
Trt	2	81	1.64	0.1997
Site*SS	4	81	1.28	0.2851
Site*Trt	4	81	0.78	0.5414
SS*Trt	4	81	0.10	0.9806
Site*SS*Trt	8	81	0.11	0.9989

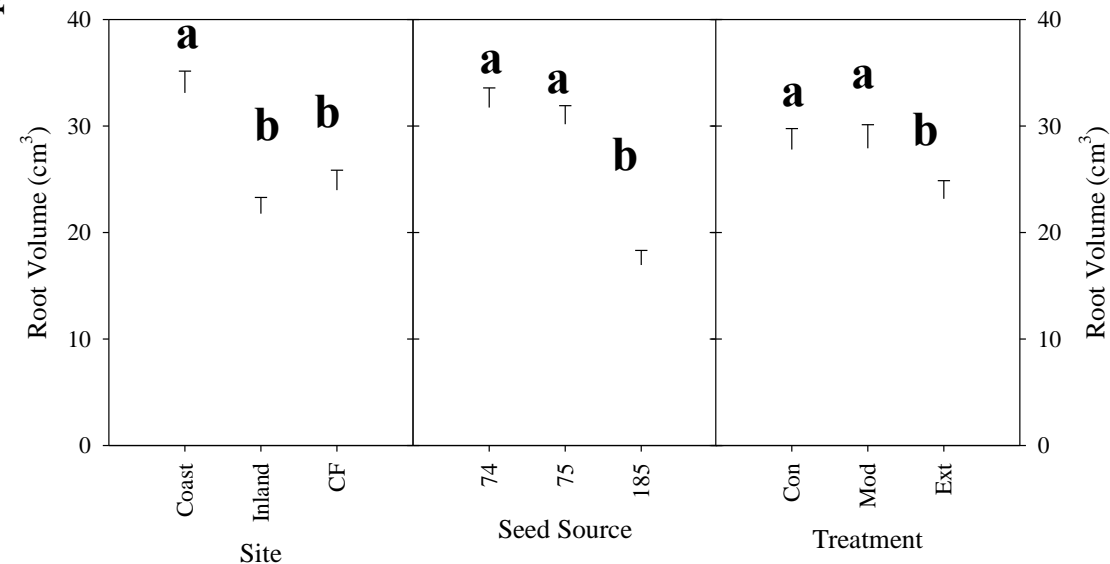


Root Volume (cm³)



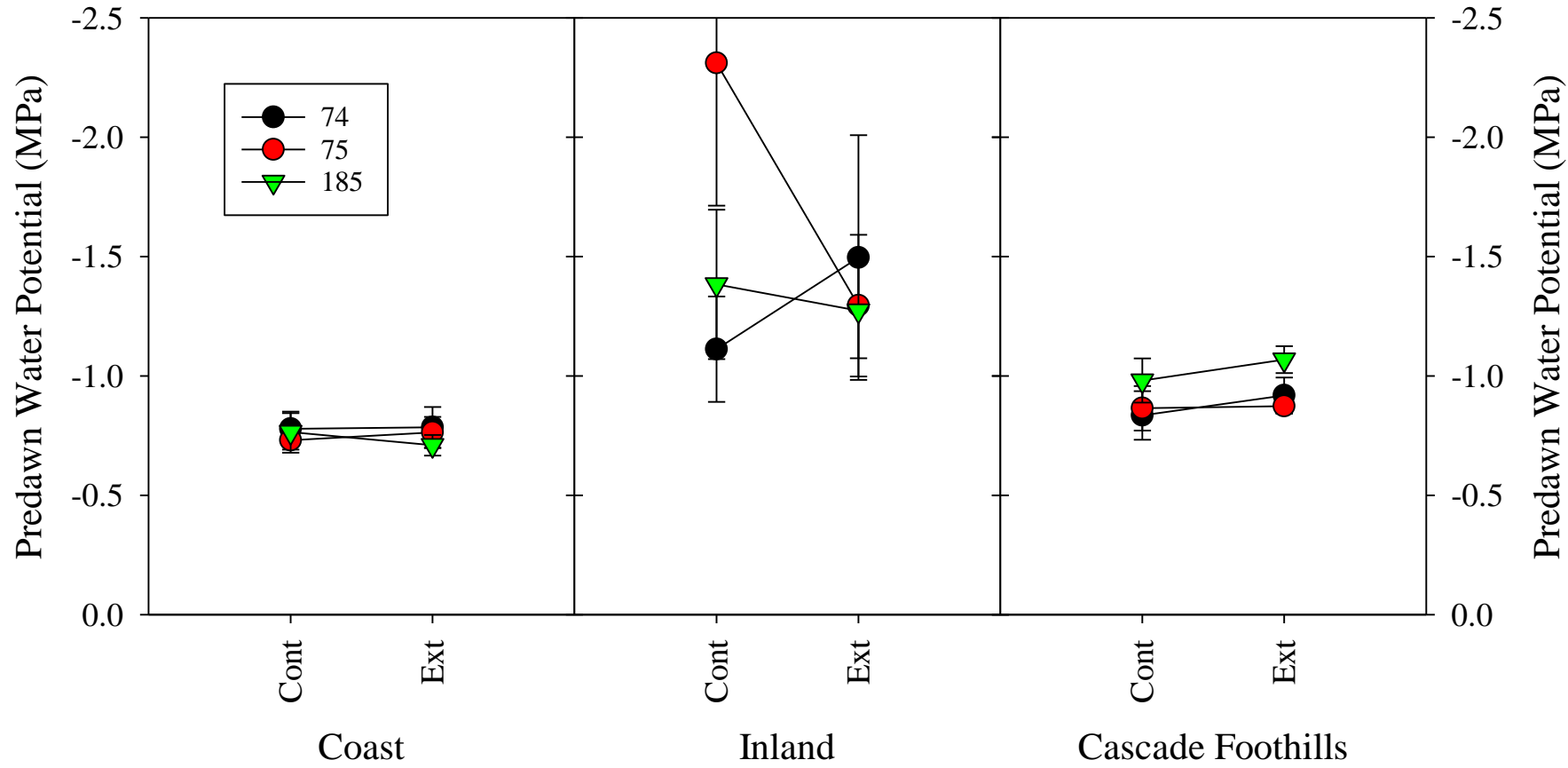
**End of Summer of First Growing Season
August**

Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	78	16.4	<.0001
SS	2	78	30.77	<.0001
Trt	2	78	3.41	0.0381
Site*SS	4	78	0.45	0.7727
Site*Trt	4	78	1.08	0.3741
SS*Trt	4	78	0.70	0.5927
Site*SS*Trt	8	78	0.56	0.8039

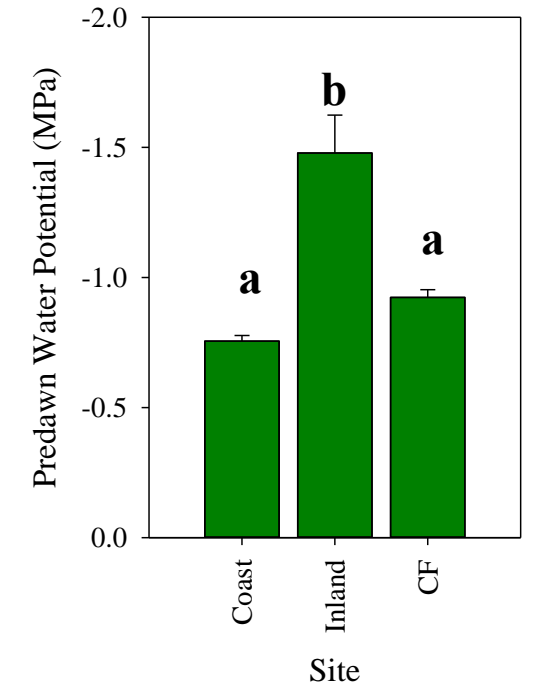


Results

Predawn Water Potential

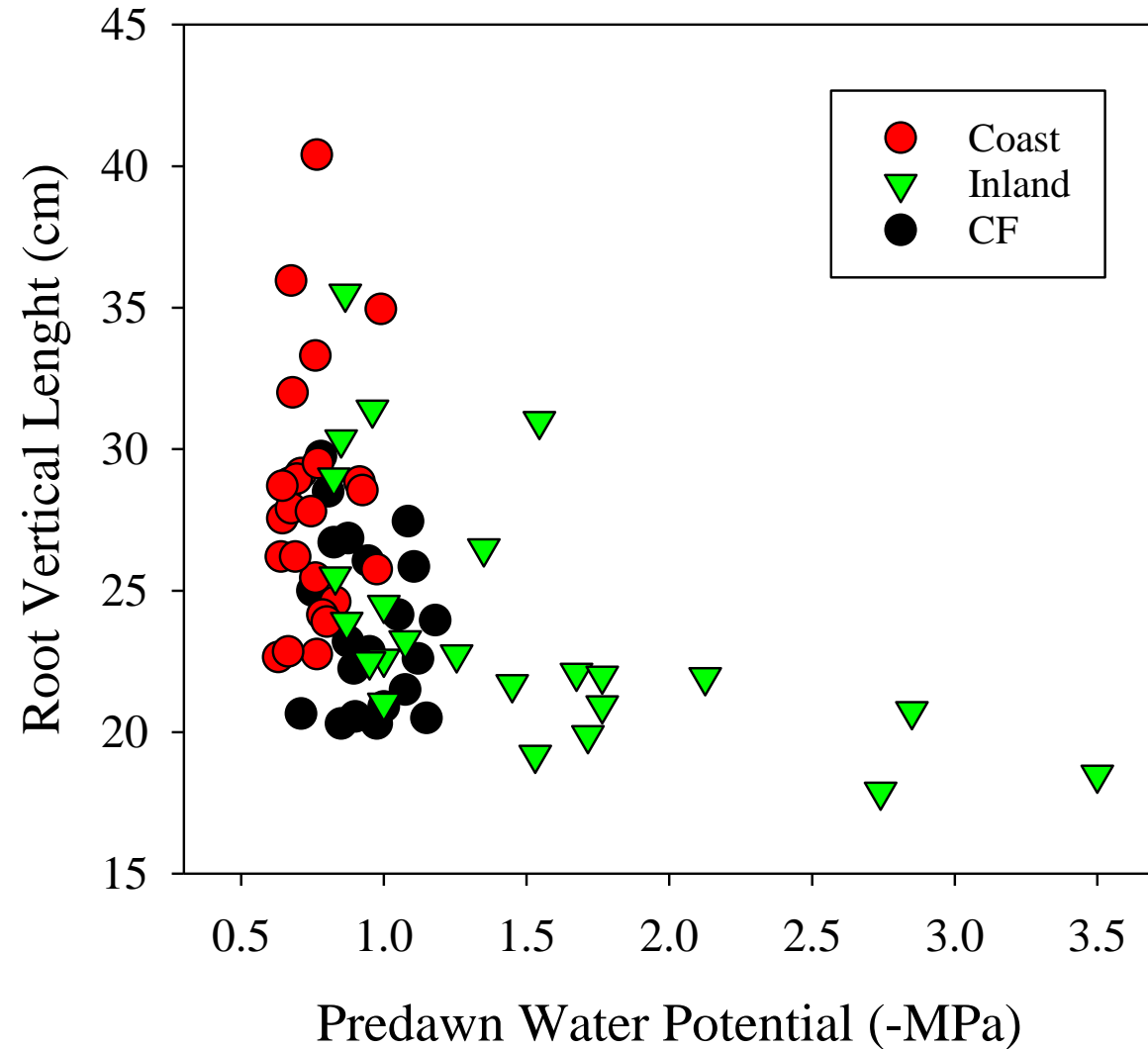


Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	51	28.65	<.0001
SS	2	51	1.23	0.2995
Trt	1	51	0.62	0.4345
Site*SS	4	51	2.29	0.0720
Site*Trt	2	51	1.31	0.2781
SS*Trt	2	51	2.97	0.0602
Site*SS*Trt	4	51	2.76	0.0380

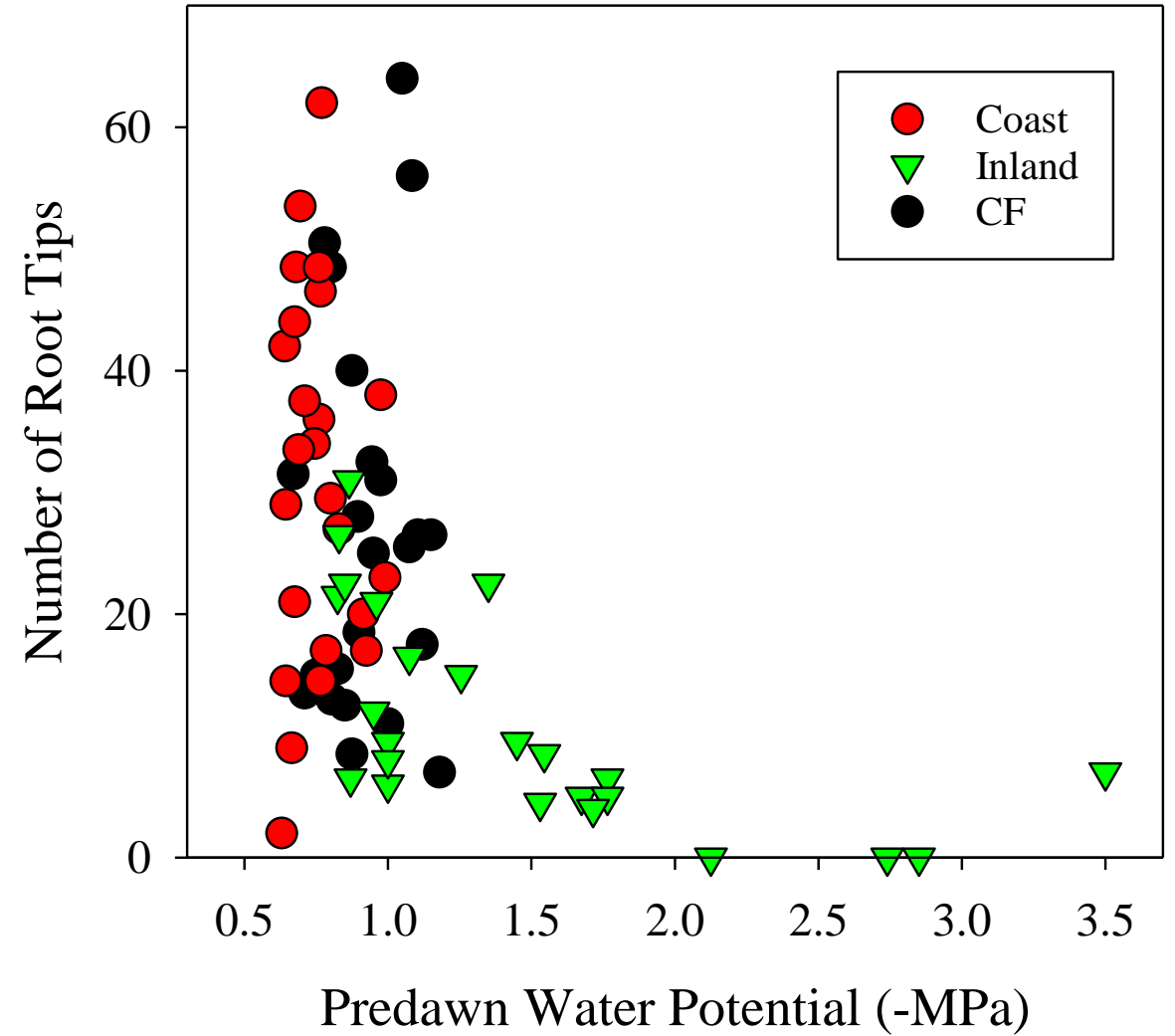


**End of Summer of First Growing Season
August**

PDWP v/s RVL



PDWP v/s NRT

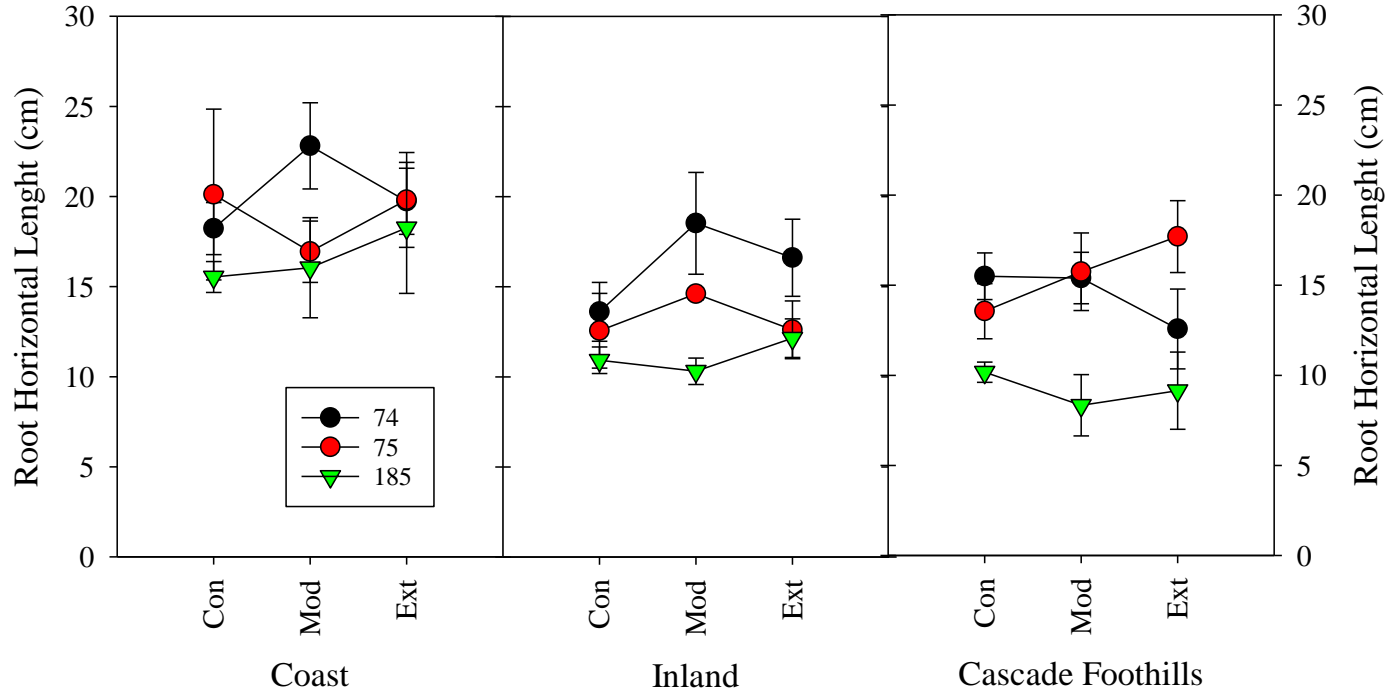


Conclusions

- **Nursery watering treatments produced seedlings with contrasting morphology, but had little effect on seedling performance**
 - **Only Extreme treatment showed reduced Root Volume (started smaller from nursery)**
- **Strong Effect of Site and Seed Source on seedling performance**
 - **Coastal Site and Inland Seed Source showed larger seedlings**
- **Strong relationship between seedling water stress (i.e. soil moisture) and root growth**
 - **Exponential decay relationship. Root growth impeded a PDWP lower than -1.2 MPa**



Root Horizontal Length (cm)

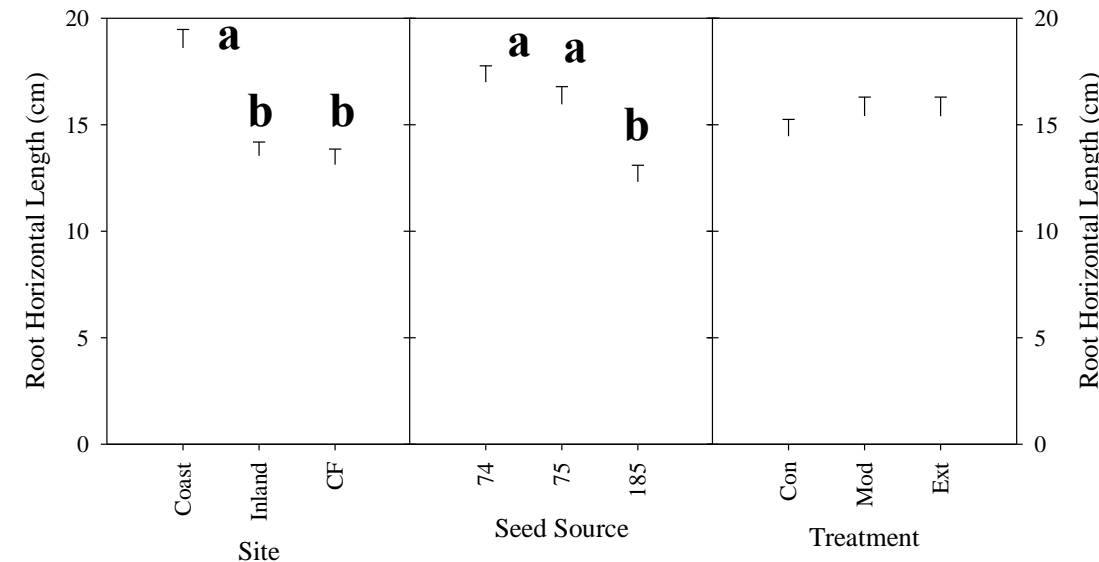


Coast – 74 - Mod

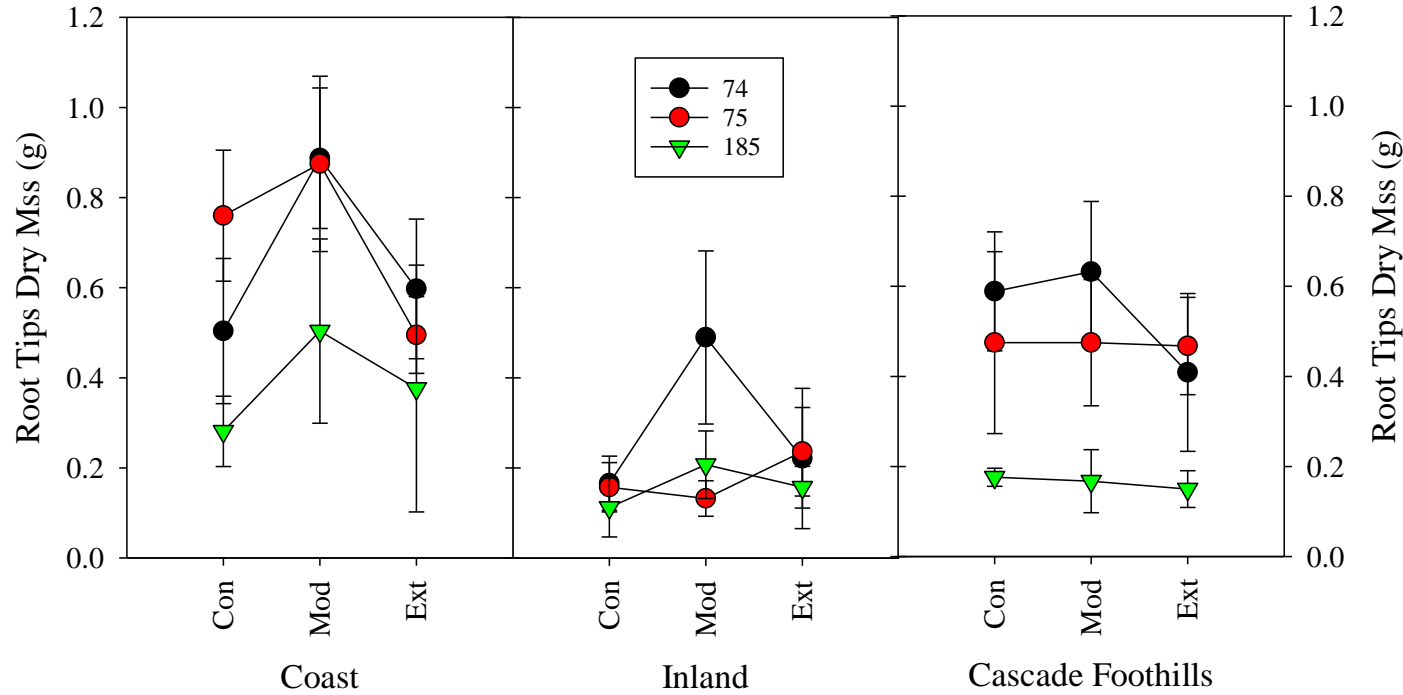


Inland – 185 - Mod

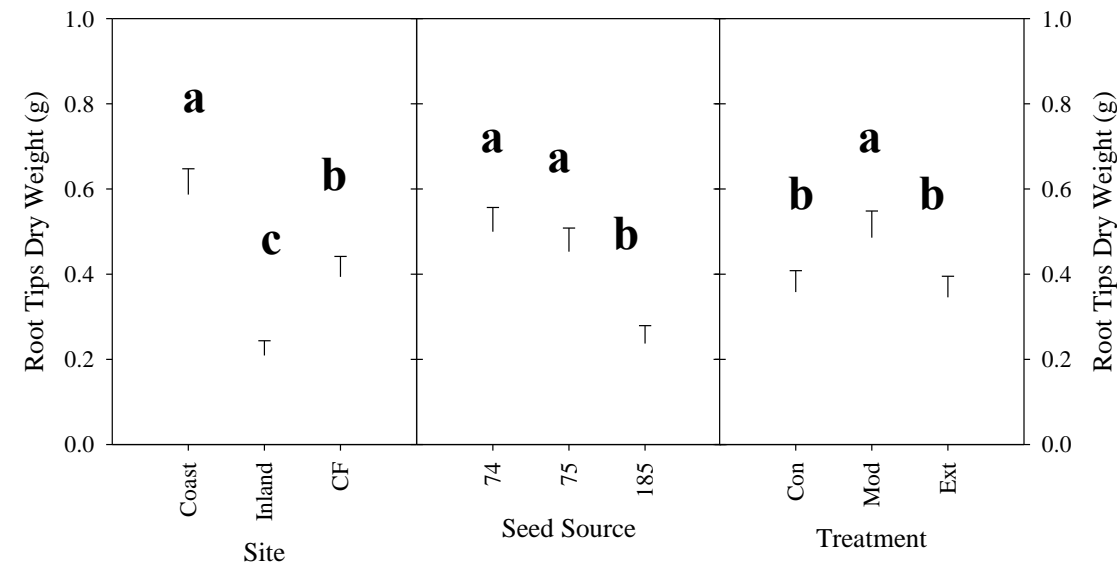
Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	81	19.3	<.0001
SS	2	81	12.54	<.0001
Trt	2	81	0.61	0.5444
Site*SS	4	81	1.29	0.2824
Site*Trt	4	81	0.25	0.9106
SS*Trt	4	81	1.05	0.3846
Site*SS*Trt	8	81	0.75	0.6480



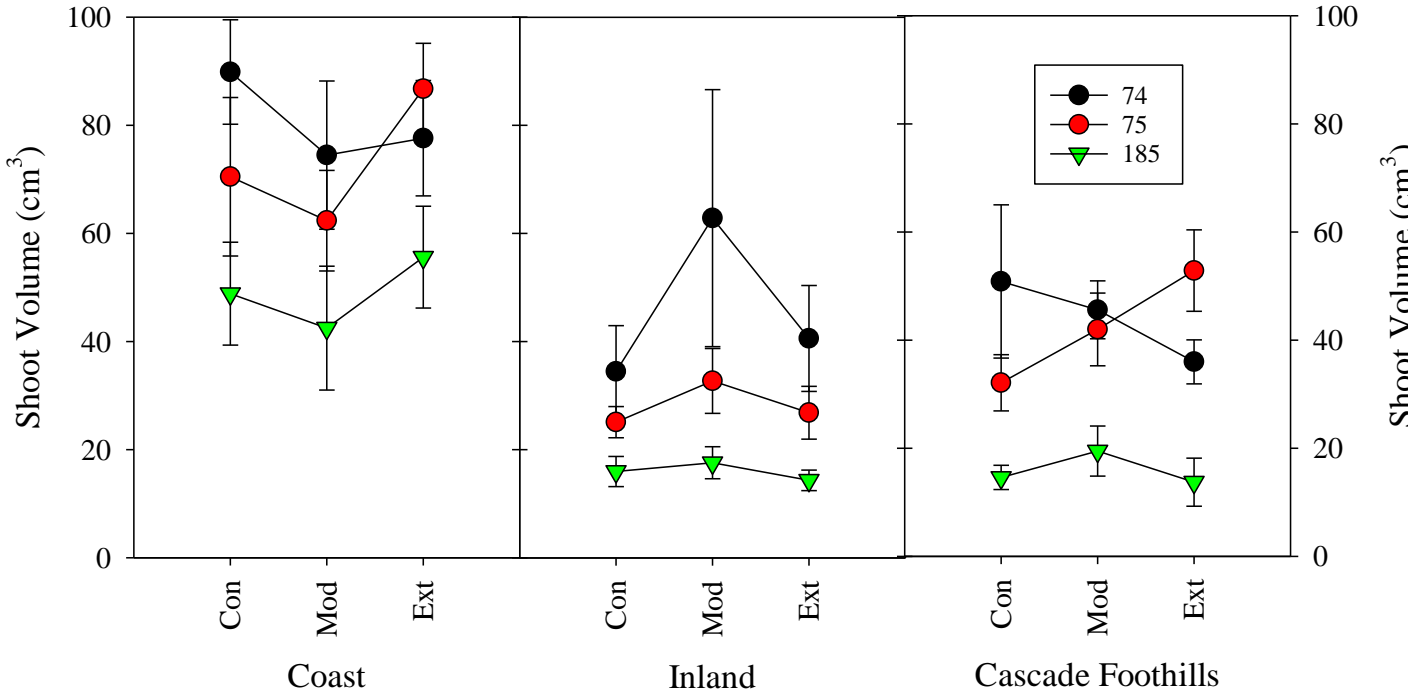
New Root Tips Dry Mass



Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	78	17.61	<.0001
SS	2	78	9.69	0.0002
Trt	2	78	2.97	0.0570
Site*SS	4	78	1.43	0.2310
Site*Trt	4	78	0.81	0.5252
SS*Trt	4	78	0.72	0.5784
Site*SS*Trt	8	78	0.41	0.9109



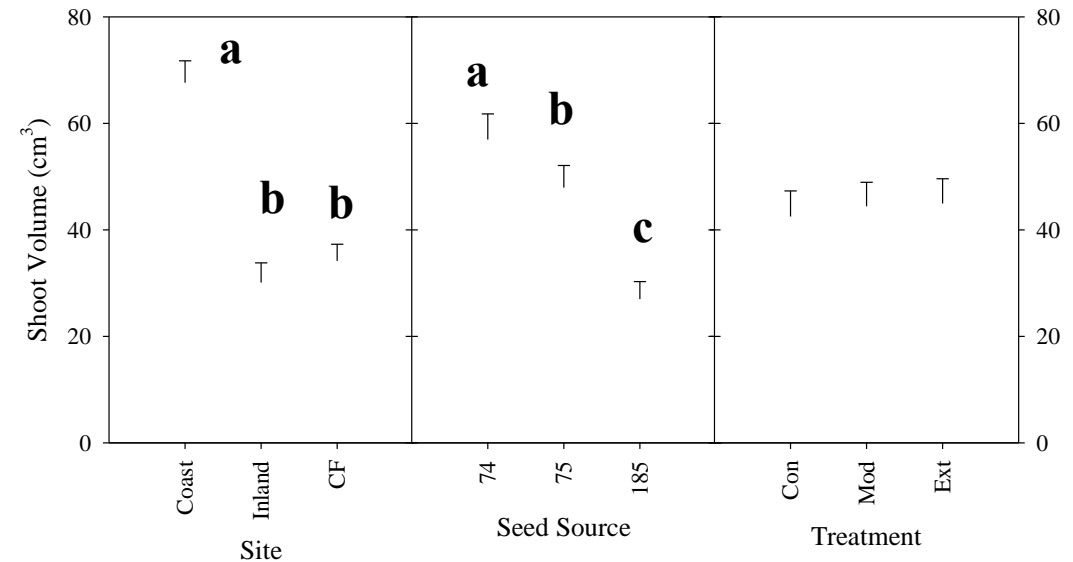
Shoot Volume (cm³)



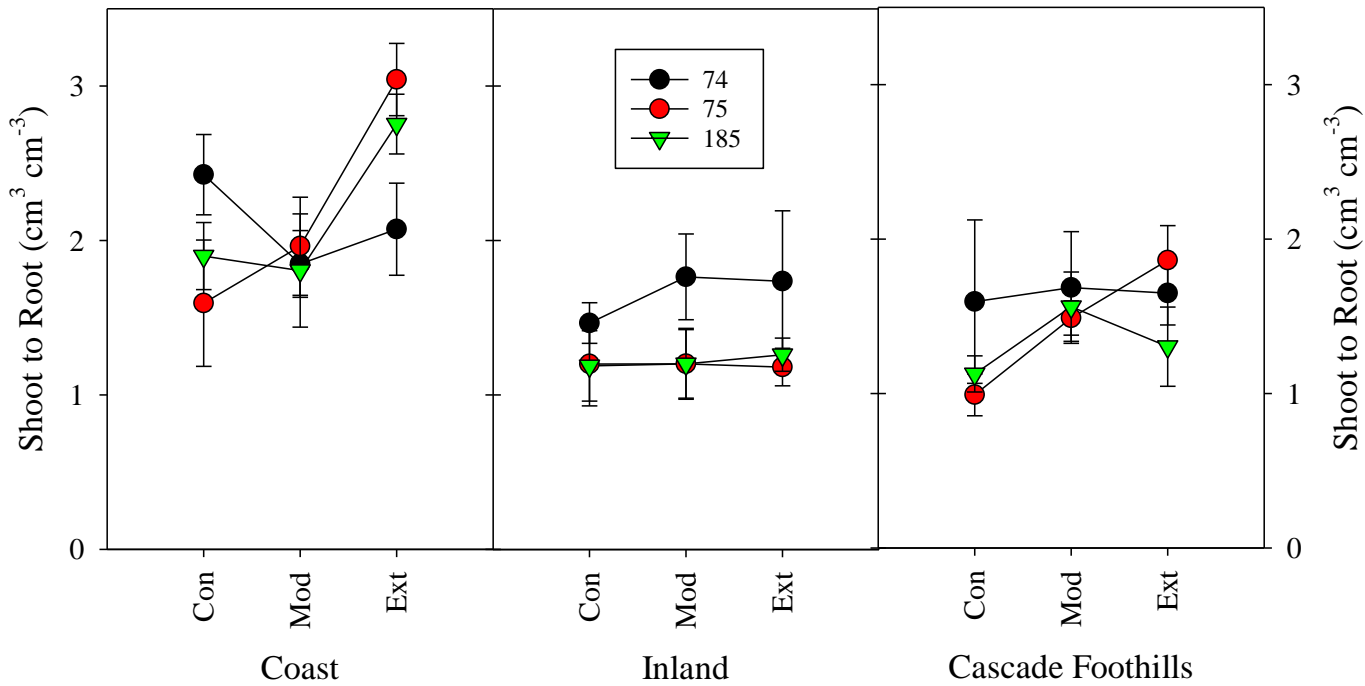
**End of Summer of First Growing Season
August**

Type 3 Tests of Fixed Effects

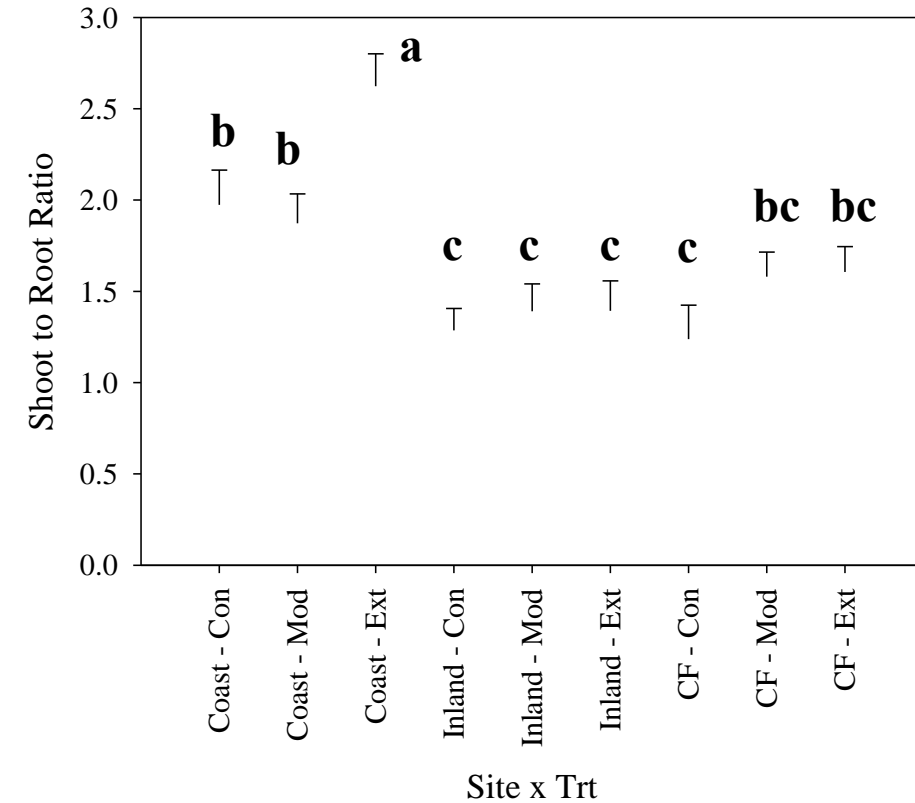
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	78	45.67	<.0001
SS	2	78	25.26	<.0001
Trt	2	78	0.18	0.8382
Site*SS	4	78	0.75	0.5620
Site*Trt	4	78	1.64	0.1730
SS*Trt	4	78	1.17	0.3304
Site*SS*Trt	8	78	0.57	0.8012



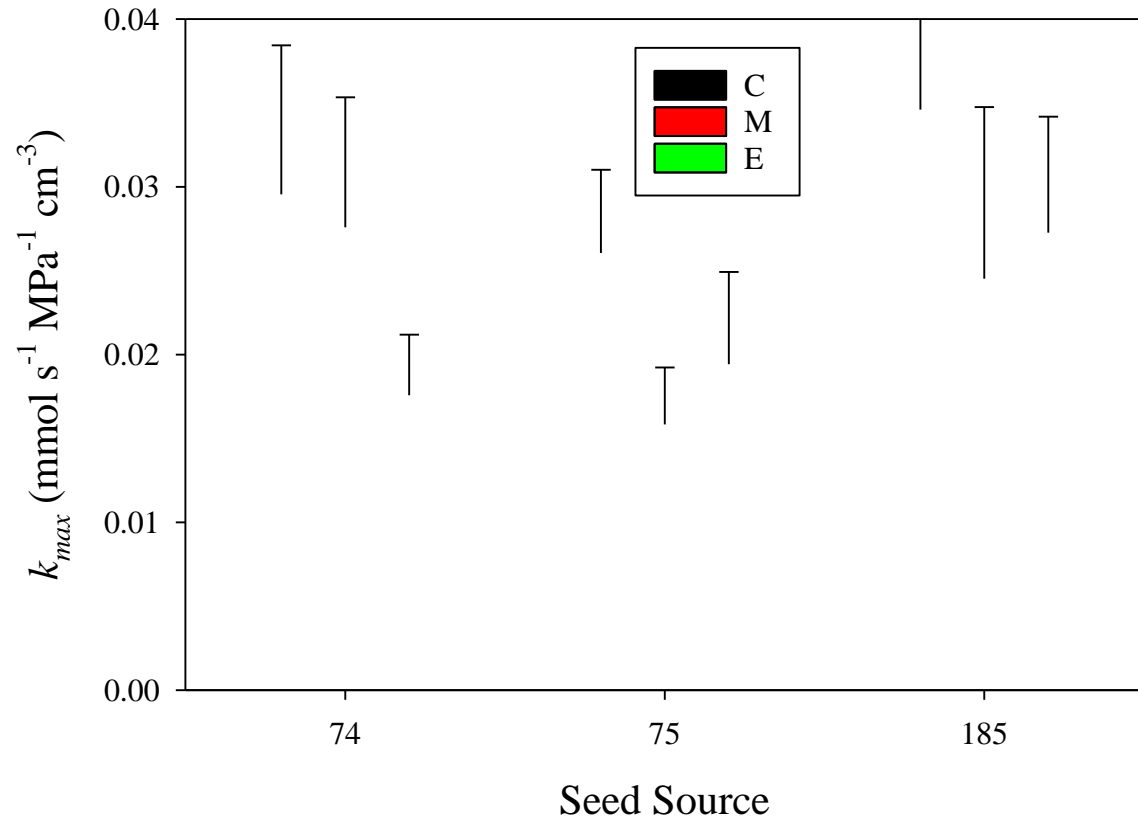
Shoot to Root Ratio (cm³ cm⁻³)



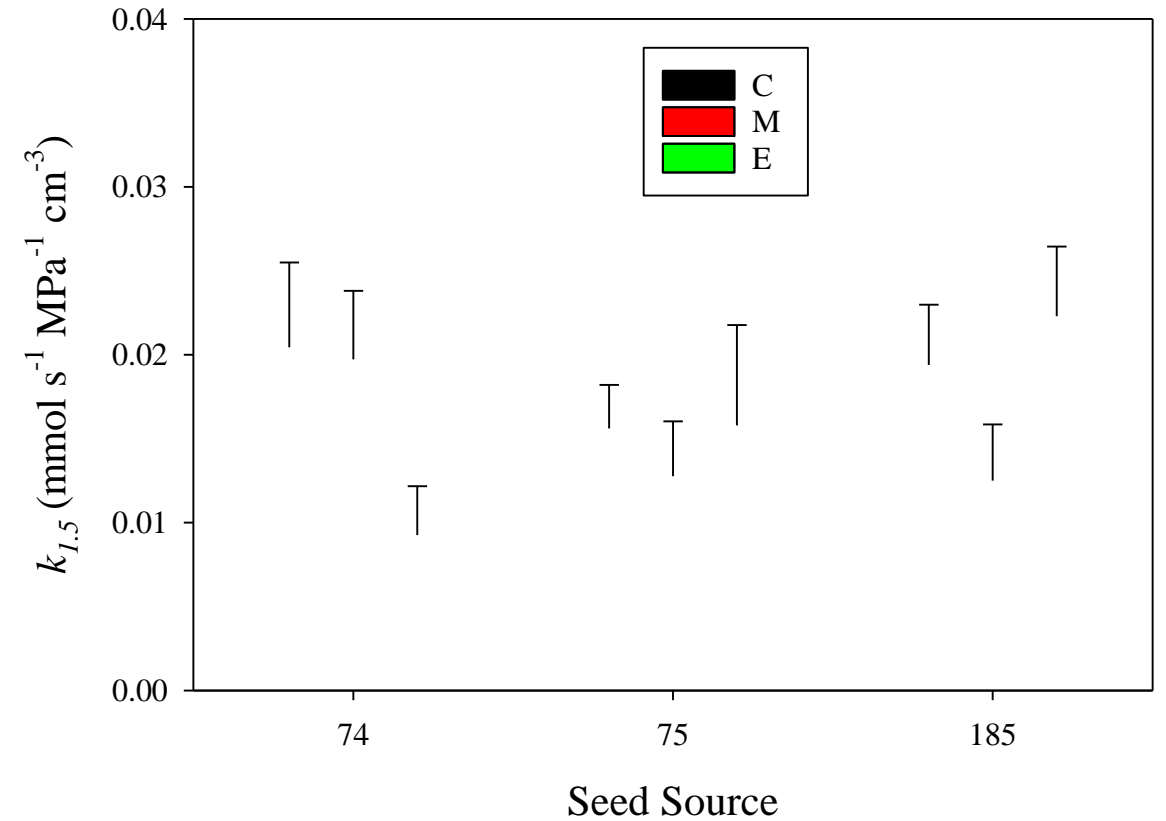
Type 3 Tests of Fixed Effects				
Effect	Num DF	Den DF	F Value	Pr > F
Site	2	78	25.63	<.0001
SS	2	78	2.19	0.1189
Trt	2	78	5.08	0.0084
Site*SS	4	78	1.07	0.3779
Site*Trt	4	78	2.32	0.0645
SS*Trt	4	78	1.73	0.1522
Site*SS*Trt	8	78	1.27	0.2715



Maximum Hydraulic Conductivity



Hydraulic Conductivity at 1.5 MPa



**At End of Nursery Watering Treatments
September**