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Rootstock Selection and Graft Compatibility of *Chamaecyparis* Species©

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INTRODUCTION

The genus *Chamaecyparis* includes many desirable and commercially important taxa. Although there are only 6 to 7 species in the genus, there is considerable variation among taxa including over 240 cultivars of *Chamaecyparis lawsoniana* alone (Krüssmann, 1985). Unfortunately, many of the *Chamaecyparis* spp. are native to cool, temperate climates and often perform poorly in stressful landscape situations, particularly under conditions of poor drainage (hypoxia), high temperatures, and *Phytophthora* spp. pathogens (Dirr, 1998; Hunt and O'Reilly, 1984). *Chamaecyparis lawsoniana* and *C. nootkatensis*, for example, are both native to the mountains of the Pacific North West and often have poor survival in less than ideal landscape settings.

Grafting poorly adapted plants onto superior rootstocks is one approach for engineering compound plants for greater environmental adaptability. Since *Chamaecyparis* species exhibit considerable ecological latitude, with some species found in cool, mountain climates (e.g., *C. nootkatensis*) while others are native to hot, boggy conditions (e.g., *C. thyoides*) (Harlow, et al., 1978), this approach (selection of tolerant rootstock) may have particular merit. There are also considerable differences in disease resistance among species of *Chamaecyparis*. *Chamaecyparis lawsoniana* is extremely susceptible to *Phytophthora lateralis* whereas *C. formosensis*, *C. nootkatensis*, *C. pisifera*, *C. obtusa* var. *formosana* (syn. *C. taiwanensis*), *C. thyoides*, and ×*Cupressocyparis leylandii* were found to be resistant (Hunt and O'Reilly, 1984). *Chamaecyparis lawsoniana* is also known to be susceptible to *P. cinnamomi* (Sinclair et al., 1987).

Opportunities for rootstock selection for *Chamaecyparis* spp. also extend beyond this genus. Limited experimentation has found that *Chamaecyparis* spp. can be grafted onto a range of different genera. Blomme and Vanwezezer (1982) reported initial graft success of up to 90% when grafting *C. nootkatensis* onto *Thuja* (syn. *Platycladus*) *orientalis*. Menerve and Istas (1975) reported satisfactory graft compatibility of *C. obtusa* 'Leonik' (syn. 'Graciosa') on *Thuja occidentalis, Cupressus arizonica* var. *glabra* 'Conica' on *P. orientalis,* and *C. lawsoniana* 'Stewartii' and 'Spek' on *C. pisifera* 'Plumosa Aurea' (though growth was reduced) over a 2-year period. Menerve and Istas (1975) further reported poor survival for *C. arizonica* var. *glabra* 'Conica' on *T. occidentalis* and *T. plicata* and for *C. obtusa* 'Leonik' on *P. orientalis*. Survival and compatibility of *C. lawsoniana* grafted on *C. formosensis* or *C. thyoides* were reported to be excellent over a 2-year period, but grafts on *C. nootkatensis* or *Chamaecyparis pisifera* were unsatisfactory (Hunt and O'Reilly, 1984). Blomme and Vanwezer (1984) recommended propagating difficult-to-root cultivars of *C. obtusa,* including 'Youngii' (syn. 'Aurea Youngii'), 'Gracilis', and 'Leonik' (syn. 'Lunik'), by grafting them on *T. occidentalis, P. orientalis,* or *C. lawsoniana*.

The objectives of this research were to evaluate candidate rootstocks for *Chamaecyparis* spp. with greater adaptability to poor drainage (inundation) and high temperatures commonly found in urban landscape situation.

MATERIALS AND METHODS

Cuttings of each species were collected in early Dec. 1999 from the JC Raulston Arboretum, Raleigh, North Carolina and the Biltmore Estate, Asheville, North Carolina. In April, 70 rooted cuttings of each species were potted into 2.8-liter (#1) black plastic containers in a pine bark and sand (8 : 1, v/v) substrate amended with dolomitic limestone at 0.9 $kg \cdot m^{-3}$ (2 lbs per yd^3) and placed on a gravel pad at the North Carolina State University Horticulture Field Lab. On 1 June, plants were moved to the Southeastern Plant Environment Laboratory (Phytotron) where two thermoperiods were initiated the following day (Day 0) using controlled-environment greenhouses. The thermoperiods were 9/15 h 30°C/26°C (86°F/79°F) or 22°C/18°C (72°F/64°F). Plants were arranged in a 10 × 2 factorial in a randomized complete block design using 10 single plant replications per treatment in each thermoperiod. The two main factors were 10 taxa (*C. lawsoniana*; Lawson falsecypress; *C. nootkatensis*, Alaska cedar; *C. obtusa*, Hinoki falsecypress; *C. pisifera*, Japanese falsecypress; *C. thyoides*, Atlantic whitecedar; ×*C. leylandii*, leyland cypress; *T. orientalis* (syn. *P. orientalis*), Oriental arborvitae; *T. occidentalis*, Eastern arborvitae; *T.* 'Green Giant' (syn.'Giganteoides'); and *T. plicata*, giant arborvitae) and two flooding periods (0 or 28 days). Flooding treatment was accomplished by inserting the growing container into an identical container lacking drainage holes, resulting in the substrate being covered by 2 cm (0.8 inches) of water. Flooding was initiated on 31 July and terminated 28 days later.

On 15 Oct., shoots (aerial tissue) were removed. Roots were placed over a screen and washed to remove substrate. Shoots and roots were dried at 62°C (144°F) for 7 days and weighed. At day 0,five plants of each taxa were separated into shoots and roots to determine initial shoot and root dry weights. Relative growth rate (RGR) for each species was calculated as follows: RGR = (ln w2 – ln w1) ÷ (t 2 – t 1), where w1 and w2 are plant part dry weight at t1 and t2. Weekly growth rate (WGR) for each species was calculated as follows: WGR = (final plant part dry weight – initial plant part dry weight) ÷ 19. Data were subject to analysis of variance procedures. Mean separations were performed using Fishers protected least significant difference (LSD) procedures, $P < 0.05$.

RESULTS AND DISCUSSION

Trees that were not flooded had 100% survival regardless of species and temperature (Table 1). Flooded trees of *C. thyoides, C. lawsoniana*, and *T. occidentalis* also had 100% survival regardless of temperature. Three additional species (*P. orientalis, T.* 'Green Giant', *T. plicata*) of flooded trees in 22/18°C had 100% survival, whereas no additional species of flooded trees in 30/26°C had 100% survival. *Chamaecyparis nootkatensis* had the lowest survival in 22/28°C (67%) and 30/26°C (58%) under flooded conditions.

Shoot and root RGR and WGR had similar results so only root RGR will be presented (Table 2). At 22/18°C, *C. lawsoniana* and *C. thyoides* had similar RGRs with only a 21% and 10% decline between nonflooded and flooded plants, respectively, whereas ×*C. leylandii* and *C. nootkatensis* had the largest decline in root RGR from nonflooded to flooded trees (213% and 55%, respectively). The good performance of *C. lawsoniana* in flooded conditions was surprising considering its poor performance in landscape plantings. This suggests that the poor landscape adaptability of *C. lawsoniana* may have less to do with intolerance to poor drainage and more with intolerance to other stresses (e.g., *Phytophthora* spp.).

Chamaecyparis thyoides performed well in both nonflooded and flooded conditions regardless of temperature (Table 2). Tolerance of *C. thyoides* to inundation is consistent with its native habitat of freshwater swamps or bogs, wet depressions, and stream banks (Harlow et al., 1978). *Thuja* 'Green Giant' and *C. lawsoniana* also performed well when flooded in 22/18°C with declines of 11% and 21% compared to nonflooded trees, respectively. However, even though *T.* 'Green Giant' and *C. lawsoniana* were also ranked 2 and 3 in flooded conditions at 30/26°C, the percent decline climbed to 46% and 43%, respectively. The remaining seven species had >50% decline in root RGR in flooded conditions at 30/26°C compared to nonflooded trees.

Table 1. Effect of temperature and flooding on percent plant survival.

Species	22/18°C		30/26°C	
	Nonflooded	Flooded	Nonflooded	Flooded
Chamaecyparis lawsoniana	100	100a[z]	100	100 a
C. nootkatensis	100	67 d	100	58 e
C. obtusa	100	92 b	100	67 d
C. pisifera	100	91 b	100	92 b
C. thyoides	100	100 a	100	100 a
×*Cupressocyparis leylandii*	100	83 c	100	91 b
Thuja orientalis	100	100 a	100	90 b
T. 'Green Giant'	100	100 a	100	83 c
T. plicata	100	100 a	100	75 d
T. occidentialis	100	100 a	100	100 a

[z]Means within columns followed by the same letter or letters are not significantly different as determined by LSD, P = 0.05.

Recent taxonomic/molecular data has provided new insights into the taxonomic relationships of taxa in the Cupressaceae. Gadek, et al. (2000) presented compelling evidence that *C.nootkatensis* should be reclassified in the genus *Cupressus*. Considering this, other species of *Cupressus, Cupressus* hybrids, and even *Juniperus* could be candidate understocks for *C.* (*Cupressus*) *nootkatensis*. These findings also help explain why *C. lawsoniana* has demonstrated poor graft compatibility with *C.*

Table 2. Effect of temperature and flooding on root relative growth rate ($mg \cdot g^{-1} \cdot week^{-1}$)[z].

Species	Nonflooded	Rank	Flooded	Rank	Decline[z] (%)
			22/218°C		
Chamaecyparis lawsoniana	103 a[y]	1	81 ab	2	21
C. thyoides	97 a	2	87 a	1	10
C. nootkatensis	69 b	3	31 cd	6	55
Thuja 'Green Giant'	65 cb	4	58 bc	3	11
T. plicata	54 bcd	5	43 cd	5	20
T. occidentalis	47 cde	6	28 c	7	40
C. pisifera	40 de	7	24 d	8	40
Thuja orientalis	33 ef	8	43 cd	4	-30
×*Cupressocyparis leylandii*	16 fg	9	-18 e	10	213
C. obtusa	14 g	10	4 e	9	17
			30/26°C		
C. thyoides	97 a	1	79 a	1	19
C. lawsoniana	74 b	2	42 b	2	43
T. 'Green Giant'	50 c	3	27 bc	3	46
C. nootkatensis	49 c	4	-2 efg	7	104
T. plicata	46 cd	5	-25 h	10	154
Thuja orientalis	46 cd	6	23 bcd	4	50
C. pisifera	30 de	7	3 def	6	90
T. occidentalis	25 ef	8	9 cde	5	64
×*Cupressocyparis leylandii*	15 g	9	-23 gh	9	253
C. obtusa	9 f	10	-13 fgh	8	244

[z]% decline = [(RGR nonflooded - RGR flooded) ÷ RGR nonflooded] × 100.
[y]Means within columns followed by the same letter or letters are not significant different as determined by
LSD, $P = 0.05$.

nootkatensis (Hunt and O'Reilly, 1984).

This research documented a wide range of tolerance to root-zone flooding among different Cupressaceae under different temperature regimes suggesting potential opportunities for using more stress-tolerant rootstocks to propagate different taxa in this family. *Chamaecyparis thyoides* demonstrated excellent tolerance to flooding and could be a desirable understock for other *Chamaecyparis* spp. when grown in poorly drained locations. However, long-term graft compatibility between these taxa needs to be determined. Preliminary grafting studies have shown good short-term graft compatibility (2-years) of *C. lawsoniana* 'Golden Showers' on *C. thyoides* 'Emily'. However, plants consisting of *C. lawsoniana* 'Oregon Blue' grafted on *C. thyoides* 'Emily' are showing considerable overgrowth of the scion at the graft union and poor anchorage. These observations may suggest that graft compatibility could be clonal-specific between certain species.

CONCLUSION

Chamaecyparis are premier ornamental plants that are used extensively in landscapes around the world. However, poor adaptability to rigorous landscape conditions often limits the use of these plants in stressful sites. This research found a wide range of tolerance to root-zone flooding among different members of the Cupressaceae that are potential understocks for *Chamaecyparis* spp. Grafting may provide an effective means for enhancing adaptability and tolerance to environmental and biological stresses by exploiting superior taxa for use as rootstocks. Additional work is currently focusing on interspecific and intergeneric graft comparability among selected species and clones.

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