White-cedar, (*Chamaecyparis thyoides* (L.) BSP), Seed Quality

at Arlingon Echo Outdoor Education Center,

Anne Arundel County, Maryland

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Introduction

White-cedar, Chamaecyparis thyoides (L.) BSP, is a coastally restricted obligate wetland tree (Laderman 1987). Little (1950) reported the difficulty of regenerating stands of this tree due to variable seed germination rates, herbivore grazing, and competition. Recruitment in white cedar stands is also effected by variation in germination rates due to poor seed quality, insect damage, and variation in embryo dormancy (USDA 1974; Laderman 1987).

White-cedar is extremely local on the Severn and Magothy Rivers, Maryland with a total of nine sites (Sheridan *et al.* In Press). Sheridan *et al*. (In Press) suggested the restoration of these white cedar habitats based on a sound ecological foundation. An essential component of white-cedar restoration in Maryland is an understanding of the factor(s) controlling the fitness of white-cedar. An effort was therefore launched to determine the germination rate and quality of white-cedar seed from Arlington Echo Outdoor Education Center, a county controlled facility with a mature stand of white cedar.

Materials and Methods

Arlington Echo was visited on October 3, 1998 and an extension pole was used to collect branches bearing cones from a total of seven trees. Diameter and position of tree within the site were recorded. Branches bearing cones were then removed from trees and both tree and branch numbered for future reference. Cones were only collected from three large trees due to the difficulty of reaching cone bearing branches, even with a 15 foot extension pole. White-cedar is self-pruning (Musselman pers. comm.) and branches are sparse to non-existent in the lower reaches of mature trees. Higher fitness of seeds from mature trees has been reported (Boyle and Kuser 1994) and I was particularly interested in obtaining seed from mature trees. Cone bearing branches were also collected from four saplings in the marsh edge at Arlington Echo.

Cones were then removed from branches and each cone individually packaged in a labeled #1 coin envelope for drying. Envelopes were placed in the drying oven on October 13, 1998 for ease of seed removal following the methods of Boyle and Kuser (1994). Envelopes were removed from the oven on October 15, 1998. Oven temperatures ranged between 35-44^{0}C.

Seeds were then manually extracted from cones, counted, the envelope labeled with the number of seeds, and seeds returned to the envelope. Debris from seed extraction was then discarded.

Once all seeds were counted, one tenth of the seed containing envelopes were randomly selected for each tree and set aside for seed quality analysis. The remaining seeds were then used to determine average mass per seed for each tree. Seed for each tree was combined into one envelope, the seeds weighed, and average mass determined by dividing total mass by total number of seeds. Seed quality was assayed by soaking the seeds for two days in tap water, cutting the seeds open with a razor blade, examining the cross section for healthy white gametophytic tissue or brown, shrunken tissue, and then placing the healthy cross sections in a 0.05% tetrazolium test to determine viability.

Results

Oven drying of seeds was not an effective way to open white-cedar cones. I found that I still had to manually "crack" many cones to get all the seeds and what was even worse was the unpredictable rise in oven temperature to 44^{0}C which could have compromised future germination experiments with this seed.

Seeds were extracted from a total of 741 cones with a yield of 5608 seeds. The average number of seeds per cone ranged from 6.4 to 8.6 depending on the tree (Table 1). Tree diameter did not appear to effect the average number of seeds per cone. There was no significant difference in average seed mass between trees and overall average mass of seed was 0.0009g (Table 2). My work on white-cedar seed from Arlington Echo in 1997 resulted in the same average seed mass as well (8647 seeds/8.2g = 0.0009g/seed).

Good quality seed (ca. 3mm in length) ranged from 1-62%, depending on the tree, with an overall average of 15.4% (Table 3. There also seemed to be an association between smaller diameter trees and better quality seed. Most seed, however, was of poor quality with an overall average of 84.6% (Table 3). Some of the poor quality seeds were also very tiny (less than a millimeter). One of the reasons for the high rate of poor quality seed was destruction of the megagametophyte and embryo by some kind of larva. Many poor quality seed contained tiny frass particles and in many cases the translucent larva was still present. Boyle and Kuser (1994) reported three categories for their poor quality seed (brown or deformed embryos, insect damage, empty). I found it very difficult to make these distinctions since these categories could have been the result of insect damage.

I was not satisfied with the accuracy of the tetrazolium test because of the difficulty in properly slicing the seed to expose the embryo. Boyle and Kuser (1994) reported a similar difficulty with tetrazolium test interpretations and instead relied on other visual aspects of seed quality as I have done in this paper.

Discussion

My germination tests with 1997 seed from Arlington Echo involved 17 trees and resulted in an average germination rate of 9% (range 4-14%) and average seed mass of 0.0009g. This experiment with 1998 seed from 7 trees resulted in the same overall average seed mass and a possible explanation for the low observed germination rate.

I originally suspected a high level of inbreeding depression in Arlington Echo white-cedar because of the limited population size (88 trees). I thought that inbreeding depression was being expressed in seed quality (hence the low germination rate) and that examination of seed would disclose deformed embryos which would support this hypothesis. I did find some deformed seed which suggests a certain amount of inbreeding but I don't think inbreeding is the major cause of low germination.

DeBarr (In Press) reported the discovery of a new pest of Atlantic white-cedar, *Megastigmus thyoides*. *Megastigmus* lays its eggs in the seeds of white-cedar and destruction of seed can be over 90% (Summerville pers. comm.). Potentially the larva observed in Arlington Echo white-cedar seed is *Megastigmus* and efforts should be made to confirm this identification and determine this species ecological interaction in the white-cedar ecosystem. No work has been done on the life cycle of *Megastigmus* (Summerville pers. comm.).

I think that the source of the low germination rate in 1997 Arlington Echo seed may be principally due to seed destruction by the parasite observed in this study. Although white-cedar seed can take up to 3 years to germinate (Laderman 1989) the low germination rate with 1997 seed (9%) can largely be explained as the result of poor quality seed (85%) found in this study. Presumably delayed germination phenomena would explain the rest of the difference. Addressing both parasitization and germination enhancement of white-cedar seed should therefore be a productive field for conservation biologists in the future.

Literature Cited

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Table 1. Average number of seeds per cone for Atlantic white-cedar at Arlington Echo

Tree number	1	2	3	4	5	6	7	Total
tree diameter	43.7	44.9	41.3	6.4	1.9	5.0	4.4	
total seeds	734	1050	1281	926	277	473	867	5608
# cones	85	129	198	125	39	60	105	741
Average	8.6	8.1	6.5	7.4	7.1	7.8	8.3	
Stnd. dev.	3.1	3.4	3.4	2.8	2.3	3.1	3.3	

Table 2. Average seed mass for Atlantic white-cedar at Arlington Echo

Tree number	1	2	3	4	5	6	7	Total
# seeds	659	935	1136	847	252	431	777	5037
mass (grams)	0.481	0.857	0.777	1.046	0.244	0.620	0.464	4.489
avg. mass*	7.2	9.2	6.8	12.3	9.7	14.4	6.0	9.0
X^2	0.19	0.001	0.055	0.112	0.002	0.143	0.075	0.407[t]

*average seed mass. x 10^{-4}
[t] Not significant, d.f. = 6, $P < 0.05$

Table 3. Seed quality of Atlantic white-cedar at Arlington Echo

Tree number	1	2	3	4	5	6	7	Total
# seeds	75	115	145	79	25	42	90	571
Good Quality #	1	14	8	27	11	26	1	88
(%)*	(1.3)	(12.2)	(5.5)	(34.2)	(44.0)	(62)	(1.1)	(15.4)
Poor Quality #	74	101	137	52	14	16	89	483
(%)*	(98.7)	(87.8)	(94.5)	(65.8)	(56.0)	(38.0)	(98.9)	(84.6)