Oxbow Farm & Conservation Center **OLLIE MACIEL OXBOW FARM & CONSERVATION CENTER**

A Tough Nut to Crack:
Mitigating the effects of *Curculio occidentis* balanophagy in nursery-grown *Quercus garryanna*

RESEARCH QUESTIONS

- **What are the best practices for finding and removing weevil-damaged acorns?**
- **Will damaged acorns still germinate? If so, will those seedlings be as hardy as those from undamaged acorns?**

INTRODUCTION

Q. garryanna (Garry oak) is the sole species of oak (Fagaceae) native to Washington[1]. Due to anthropogenic impact, an estimated 3% of *Q. garryanna* habitat remains in Washington[2]. Garry oak saplings are subject to browsing and shading out, making nursery-grown trees ideal for restoration over direct acorn sowing[3].

C. occidentis (filbert weevil) is a species of balanophagic (acorn-feeding) weevil native to WA[4]. In its larval stage [Fig. 1], it feeds on cotyledon tissue in the acorn[5] [Fig. 2, Fig. 5]. Eggs are laid into young acorns, in which larvae feed until autumn[4]. Mature larvae then chew through the shell, leaving behind an emergence hole [Fig. 3][6].

Nursery growers may wish to cull damaged acorns as to not invest space and labor on seeds that may not germinate or produce robust plants[5]. However, there is scarce evidence of larval presence until one emerges, making it difficult to remove damaged acorns from a lot of seeds.

FIGURES

FIG. 1
Mature larva of *C. occidentis*, (10x).

FIG. 4
A moderately damaged acorn showing signs of maturation, despite damage to the cotyledons. The intact apical meristem is visible in the center.

FIG. 2
Moderately damaged acorn.

FIG. 5
A highly damaged acorn, with a larva still inside.

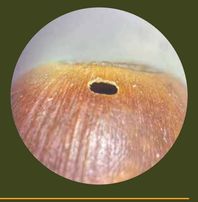

FIG. 3
An emergence hole, located at the cap end of the acorn (10x).

EVALUATION OF SCREENING METHODS

ACORN SCREENING AND CONTROL APPROACHES

Established culling methods documented in the literature:

- Visual inspection[6, 7]
- Float testing[5, 6, 8, 9, 10, 11, 12]

Additional prevention and control strategies for *C. occidentis*:

- Controlled burns[14]
- Applications of nematodes[15]

Emerging method:

- Cold storage has not been scientifically evaluated in *Q. garryanna*; however, it shows promise for encouraging larval emergence from acorns[13].

VISUAL EXAMINATION

Acorns are visually assessed during harvest or processing for emergence holes (Fig. 2).

- Larvae do not emerge simultaneously; a visually undamaged acorn may still contain larvae.
- A 2017 study found visual examination to be more accurate than float testing in finding damaged acorns of *Q. alba*[7].
- May be time consuming for growers looking to screen large quantities of acorns.

FLOAT TESTING

In theory, damaged acorns are less dense and float in water, while sound acorns sink. This method allows for quick screening of large seed lots.

Numerous studies both questioning and supporting the efficacy of float testing acorns have been published:

- Dried out acorns are less dense and will float, meaning sound acorns may be culled[8, 9].
- Up to 44% of floating acorns of *Q. rubra* were found to be viable via dissection[9].
- USFS recommends soaking acorns for 24 hours prior to float testing, while others suggest collecting acorns shortly after rainfall or from otherwise damp areas[6, 8].

In a single study focusing on *Q. garryanna*, the float test was found to be highly accurate[5]:

- Weevil-free acorns represented 96% of those that sank.
- Only 6% of floating acorns were found to have no insect damage.
- 77% of floating acorns had more than 50% of their cotyledon tissue damaged.
- 88-96% of sinking acorns germinated (avg. germination for Q. garryanna is 80%).

COLD STORAGE

Refrigeration simulates autumn weather, signaling to the larvae inside that it is time to emerge.

- Though acorns are recalcitrant, germination rates of 90% are achieved even after 25 months at 1.6°C (in gas-permeable bags with adequate humidity)[13].
- Acorns may germinate in storage, but this will not impact their growth; if radicles are damaged sowing, seedlings develop multiple taproots at the breakage site[13].

At Oxbow, in a batch of acorns that had already been visually screened for weevils, an additional five weevils emerged after 10 days in cold storage at 4.4°C.

PERFORMANCE OF DAMAGED ACORNS

GERMINATION

Most float test studies did not directly measure germination success and instead assumed that any insect damage made acorns nonviable. Evidence suggests otherwise. **If the embryo remains intact, damaged acorns are still capable of germination**[5] [Fig. 4]. Reported germination rates vary widely: one study (2006) found that 84% of damaged *Q. garryanna* acorns germinated[12], while an earlier study (1999) reported only 11.5%[3].

SEEDLING VIGOR

Like many oaks, *Q. garyanna* germinates taproot-first, with cotyledons emerging later[12]. Since balanophagy occurs primarily on the cotyledons, it is possible a seed may pass a germination test with the emergence of a radicle, but will fail to produce a vigorous seedling later down the line. Lacking an endosperm, acorns rely on the cotyledons for energy[3, 8].

A study on *Q. rubra* determined that weevil-damaged acorns produced trees with normally sized taproots, but fewer leaves, fewer leaf flushes, a shorter shoot length, and overall less dry mass when compared to undamaged acorns[16]. At present, only study has observed that damaged *Q. garryanna* acorns produce seedlings with shorter taproots than undamaged ones, but no studies have tested shoot growth metrics[12].

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CONCLUSIONS

- **No single screening method has been shown to be consistently most effective for *Q. garryanna*.**
- **Growers must weigh trade-offs:** Consider whether time spent culling damaged acorns by visual screening or prolonged refrigeration is worth savings in labor and space later on.
- **Float testing has limitations:** Account for the inaccuracy of the test and anticipate both losing viable acorns and sowing damaged acorns.
- **Damaged acorns can still germinate:** Screening may not be necessary for germination; however, long-term seedling quality remains uncertain.