Photo by David H Peter

Acorn storage alternatives tested on Oregon white oak

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ABSTRACT

We assessed various combinations of storage factors: bag type, temperature, duration, and antifungal pre-storage treatments for white oak acorn storage, using Oregon white oak (*Quercus garryana* Douglas ex Hook. [Fagaceae]) acorns from 7 seed sources. Acorn viability remained high (84%), even after 2 y of refrigerated storage, but the majority of these acorns germinated between 6 and 12 mo after entering storage. Germination during storage differed significantly by seed source. The likelihood of successful storage of Oregon white oak acorns was increased by placing washed, healthy-appearing acorns in storage at a near-freezing temperature (1.6 °C [35° F]) soon after collection. Sealed conventional freezer bags or specialized gas-permeable plastic bags were equally effective in maintaining viability. For 6-mo storage under the best treatment combination, 77% of acorns remained viable but ungerminated in storage, compared to 89% viability prior to storage.

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germination, seeds, *Quercus garryana*

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Oregon white oak (*Quercus garryana* Douglas ex Hook. [Fagaceae]), the only oak species native to northern Oregon, Washington, and British Columbia, is an important structural component of oak woodland and savanna ecosystems in the Pacific Northwest. Oregon white oak is a shade-intolerant, deciduous tree capable of growing on a wide range of sites, but it is most often found in lowland areas where conifers were historically excluded by Native American burning practices (Agee 1993). Oregon white oak habitat has been substantially diminished by conifer encroachment and by land use changes including urbanization and agriculture. In recent years there have been significant efforts to restore Oregon white oak and associated prairie habitats in the US and Canada (Hanna and Dunn 1997). This restoration work often includes planting oak seedlings (Devine and others 2007). As with many other oak species, acorn production by Oregon white oak populations in the coastal Pacific Northwest varies substantially from year to year (Peter and Harrington 2009). Thus, a local seed source is not available every year, and storage of acorns is especially desirable following a mast year. Also, storage between fall collection and spring sowing is sometimes undertaken to reduce predation on sowed acorns during winter months. There has been no research on storage of Oregon white oak acorns until now; however, numerous studies of acorn storage techniques for other oaks provide guidance and also indicate that ideal storage conditions vary by species (Bonner and Vozzo 1987; Connor and Bonner 1999).

Storage of acorns in the white oak group *(Lepidobalanus)* is challenging because they are recalcitrant and therefore must retain a high amount of moisture to remain viable (Bonner and Vozzo 1987) (Figure 1). For many white oaks, safe moisture levels during storage are around 45 to 50% (Bonner 2008). Long-term storage under low-humidity refrigeration may gradually desiccate acorns and reduce viability. Acorns maintain a relatively high metabolic rate, and because they consume oxygen and release carbon dioxide through respiration, they will not remain viable if stored in containers impermeable to these gases. For acorns stored in bags, the composition of the bag material, the bag wall thickness, and the seal of the bag opening all affect gas exchange (Rink and Williams 1984; Bonner 2008).

White oak acorn storage is further complicated by the fact that they have

TABLE 1

Acorn storage treatments in 2 experiments, consisting of combinations of storage bag type, temperature, and antifungal treatment.

Bag type	Temperature (°C)	Antifungal treatment	Storage duration (calendar months)
Experiment 1			
Perforated Skilcraft 2-mil seal closure bag [z]	4.0 [w]	soap wash	2, 4, 6, 8, 12
Ziploc 2.7-mil quart freezer bag [y]	1.6 [v]	soap wash	2, 4, 6, 8, 12
Star*Pac gas-permeable bag [x]	1.6	soap wash	2, 4, 6, 8, 12
Experiment 2			
Star*Pac gas-permeable bag	4.0	soap wash	7, 13 [u]
Star*Pac gas-permeable bag	1.6	soap wash	7, 13, 19, 25 [u]
Star*Pac gas-permeable bag	1.6	soap wash, bleach	7, 13, 19, 25 [u]
Star*Pac gas-permeable bag	1.6	soap wash, Captan	7, 13, 19, 25 [u]

[z] A basic sealable plastic bag, made of low density polyethylene (Envision Inc, Wichita, Kansas).
[y] A sealable bag made of polyethylene (SC Johnson & Son Inc, Racine, Wisconsin).
[x] Star*Pac polyethylene bags are gas permeable and liquid impermeable (Garner US Enterprises Inc, Willis, Texas).
[w] Standard refrigerators used for storage at 4.0 °C (39 °F).
[v] Precision-controlled refrigerators used for storage at 1.6 °C (35 °F).
[u] Includes 1 additional month during which acorns in Experiment 2 were stored at 4 °C before storage treatments were initiated.

no embryo dormancy or stratification requirement and are prone to germinating during storage (Connor 2004). To reduce germination during storage, acorns are usually stored at temperatures near freezing. Storage at these temperatures also slows their metabolic activity, which reduces gas exchange and the likelihood of oxygen depletion or excessive carbon dioxide accumulation. An additional benefit of cold temperatures is that the rate of fungal growth, which may damage newly sprouted radicles, is reduced.

Our study objective was to examine the response of Oregon white oak acorns to a variety of simple, inexpensive storage treatments at storage lengths of 2 to 25 mo (Table 1). Most of the treatment combinations tested have not been formally compared for any species of oak.

METHODS

Acorn Sources

In late August and September 2006, we collected acorns from 7 seed sources in Washington (Table 2; Figure 2): 6 sources in the South Puget Sound region (Thurston and Mason counties) and 1 in the Columbia River Gorge (Klickitat County). The Thurston and Mason seed sources are all within 24 km (15 mi) of the city of Olympia; elevation ranges from 60 to 160 m (200 to 520 ft), and mean annual precipitation is 1288 mm (50.7 in). The Klickitat County source is at an elevation of 400 m (1320 ft), with mean annual precipitation of 348 mm (13.7 in). The 7 seed sources were selected from trees that were part of a regional acorn survey (Peter and Harrington 2009); these 7 sources were chosen because in past years it was possible to obtain a large number of acorns from a single tree or a cluster of trees.

We placed all acorns in refrigeration at 4.0 °C (39.2° F) until the beginning of the 2 storage experiments. At the initiation of the first experiment (Experiment 1), we float-tested all of the acorns and discarded those that floated, had obvious damage, or were very small compared to the average size for that seed source. We washed the remaining 8500 acorns for 1 min in a dilute soap solution (3 to 4 drops liquid soap per gallon water), air-dried them 24 h, and then divided them among the 2 experiments, reserving approximately 100 acorns per seed source for an initial assessment (that is, month 0) of germination percentage. Acorns for Experiment 2 were returned to temporary storage (4.0 °C) until that experiment began.

At the initiation of each experiment, acorns were divided into experimental units consisting of 15 to 32 acorns from a single seed source in a storage bag. We based the number of acorns per bag on the number collected from each seed source, but in most cases it was 30. The 7 seed sources were split between the 2 experiments (4 in Experiment 1; 3 in Experiment 2) because insufficient acorns were available

Figure 1. In their natural environment, these Oregon white oak acorns germinated in late fall after seasonal rainfall had thoroughly moistened litter and soil. Photo by Joseph Kraft

Figure 2. Acorns from the WalMart, Tree 42, and Rock Creek seed sources (left to right). Photo by Joseph Kraft

from a single source to represent all treatments and replications across both experimen ts.

Experiment 1

Experiment 1 began 5 October 2006. Treatments consisted of combinations of storage temperature, storage bag type, and storage duration (0 to 12 calendar months) (Table 1). We selected the temperatures to represent standard refrigeration (4.0° C) and precision-controlled refrigeration set at just above freezing (1.6° C; 34.9° F). Actual temperatures for both experiments were 4.03 °C (39.25° F) with a standard deviation of 0.87 °C (1.57°F) and 1.59 °C (34.86° F) with a standard deviation of 0.03 °C (0.05° F). We used 3 types of labeled polyethylene bags: basic sealable 2-mil Skilcraft™ bags that had been perforated to allow gas exchange, sealable 2.7-mil Ziploc® freezer bags, and Star*Pac® bags that are permeable to gas but not to liquid. We are unaware of any previous tests of Star*Pac bags for acorn storage.

The perforated Skilcraft bag (4.0°C) treatment was selected to represent the conventional approach to small-scale acorn storage. Prior to storage, the openings of all bags were sealed.

Experiment 1 consisted of 3 replications (separate refrigeration units) x 3 storage treatments x 4 seed sources x 5 storage durations = 180 experimental units. At the end of each of the 5 storage durations, a total of 36 of the experimental units were removed from storage for germination assessments (below).

Experiment 2

We designed Experiment 2 to supplement Experiment 1 by testing longer storage durations; treatments ranged from 0 to 24 mo after a 1-mo temporary storage period at 4.0 °C before the formal treatments were applied. Previous experience indicated that fungal growth increases at longer storage durations, so we included a test of antifungal treatments. Experiment 2 began 30 October

2006. Treatments consisted of combinations of storage temperature (1.6 °C and 4.0 °C), antifungal pre-storage treatments, and storage duration (0 to 24 calendar months) (Table 1). The antifungal treatments, applied immediately before placing acorns in sealed storage bags, consisted of washing acorns with a dilute soap solution, and then either: 1) washing acorns in a solution containing 95% water and 5% bleach by volume; 2) dusting acorns with Captan fungicide (Drexel Chemical Company, Memphis, Tennessee) so that each acorn was coated with a dusting of the fungicide; or 3) no further treatment before storage. Experiment 2 consisted of 3 replications (separate refrigeration units) x 4 storage treatments x 3 seed sources x 5 storage durations. Experimental units were the same as in Experiment 1, with typically 30 acorns per bag.

Data Collection and Analysis

Prior to storage, we sampled 20 acorns per seed source to determine initial moisture content and mean dry weight per acorn. We also tested initial germination percentage for each seed source using 4 replications of approximately 25 of the float-tested acorns. That test, and all post-storage germination tests, were performed by placing acorns on germination paper in a plastic germination dish inside a sealed Star*Pac bag and putting the bags in an Enconair germinator (BioChambers Inc, Winnipeg, Manitoba) set at a 10-h 18°C (64 °F) day / 14-h 12 °C (54 °F) night regime. We monitored germination (defined as the emergence of a visible radicle) every 5 to 6 d for up to 2 mo, or until all acorns either had germinated or were clearly nonviable. For the 12- and 13-mo storage duration in Experiments 1 and 2, we measured the lengths of the radicles that had emerged while acorns were in storage.

HOBO Pro dataloggers (Onset Computer Corporation, Bourne, Massachusetts) were used to record the temperature in each refrigeration unit at 10-min intervals throughout the storage period.

We removed the first bags from storage on 5 December 2006 (2-mo treatment of Experiment 1) and thereafter at designated intervals until the final bags were removed on 30 October 2008 (25-mo treatment of Experiment 2). At each removal date, we counted the number of acorns in each bag that germinated during storage and then tested percentage germination of the remaining acorns using the procedure described above. Two hundred of the acorns that germinated during the 19- and 25-mo storage treatments were subsequently planted in pots to assess their viability.

Three germination values were analyzed separately within each experiment: 1) the percentage of acorns placed in storage that germinated during storage; 2) the percentage of acorns placed in storage that were ungerminated at the end of storage but subsequently germinated in a post-storage germination test; and 3) total germination, defined as the sum of the percentages in (1) and (2). We analyzed the data from each exper-

TABLE 2

Pre-storage dry acorn weight, moisture content, percentage initial germination, percentage germination during storage (top number) and percentage of acorns placed in storage that were ungerminated at the end of storage but still viable (that is, post-storage germination; lower, italicized number) for Oregon white oak acorns from 7 Washington seed sources.

Seed source	Collection date	Pre-storage dry acorn weight (g)	Moisture content (%)	Initial germination (%)	Percentage germination during storage and post-storage 6/7 mo [z]	12/13 mo
Experiment 1						
South Pipeline	27–28 Sep	3.1	40	88 A	2 D *77 a*	52 AB *29 cd*
Scatter Creek	27–28 Sep	2.1	46	77 A	22 CD *61 ab*	67 A *13 d*
Weir Prairie	27–28 Sep	2.5	44	92 A	14 CD *70 a*	39 BC *40 bc*
Wolf Haven	27–28 Sep	2.5	43	89 A	6 D *79 a*	62 AB *17 cd*
Experiment 2						
Rock Creek	21 Aug	2.5	59	94 A	93 A *4 b*	95 A *2 b*
Tree 42	24 Sep	2.2	41	98 A	19 B *63 a*	79 A *2 b*
WalMart	27–28 Sep	2.7	43	97 A	25 B *63 a*	77 A *18 ab*

Note: Within each experiment, initial germination and during-storage germination values accompanied by the same uppercase letter do not differ, and post-storage germination values accompanied by the same lowercase letter do not differ. Mean separation was conducted at the 95% confidence level using Tukey's HSD test.

[z] Acorns in Experiment 2 were stored at 4 °C for approximately 1 additional month before treatments were initiated.

iment separately using analysis of covariance, with storage treatment and storage duration as fixed effects, replication as a random effect, and initial germination percentage for each seed source as a covariate (The MIXED Procedure; SAS Institute 2003). We ran a separate analysis of variance to compare 6- and 12-mo germination percentages among seed sources within each experiment. Mean comparisons were made using Tukey's HSD procedure with an experiment-wise confidence level of 95% (Zar 1999). Each model was tested for heteroscedacity and normality of residuals; where necessary, data were transformed using the arcsine-root transformation (Zar 1999).

RESULTS,

Mean acorn dry weight averaged 2.5 g across all 7 seed sources (Table 2). Initial acorn moisture content for Rock Creek averaged 59%, while all other seed sources were between 40 and 46%. Initial germination averaged 91% across both experiments, and we noted no significant differences among seed sources within either experiment. Percentage germination during 12-mo storage differed among seed sources in Experiment 1, with Scatter Creek (67%) significantly higher than Weir Prairie (39%). The percentage of viable acorns that did not germinate during 12-mo storage was less for Scatter Creek than for Weir Prairie (13 versus 40%). In Experiment 2, percentage germination during 7-mo storage differed by seed source: Rock Creek (93%) was significantly higher than the Tree 42 (19%) and WalMart sources (25%). Conversely, the percentage of viable acorns that did not germinate in storage was lowest for Rock Creek (4%) at 7 mo.

Total germination percentage remained generally high across all treatments in both experiments (Table 3). Although we detected no statistically significant differences in total germination among treatments at any storage duration in either experiment, we noted significant differences among storage durations within treatment. In Experiment 1, total germination declined significantly to 69% for 12-mo storage in perforated bags at 4.0^{o}C. For Ziploc freezer bags, 4-mo storage had the lowest total germination although this value was not part of an obvious trend. In Experiment 2, 13-mo storage showed a significant reduction in total germination for acorns in Star*Pac bags at 4.0^{o}C. After 25-mo storage, total germination in the three 1.6 °C treatments was 77 to 90%.

The percentage of acorns germinating during storage in Experiment 1 did not differ significantly by treatment at any storage duration, but at 4- to 8-mo storage durations, the perforated bags at 4.0 °C trended higher than the other 2 treatments (Table 4). In the two 1.6 °C treatments, germination in storage remained low (9 and 10%) at 6 mo, but increased significantly by 12 mo (52 and 54%). In Experiment 2, germination in storage was relatively high at 7 mo (37 to 62%) and very high by 13 mo (75 to 84%), with the exception of the Star*Pac 4.0 °C treatment which had 42% storage germination after 13 mo.

Among the stored acorns, a relatively high percentage (72 to 82%) remained ungerminated but viable in Experiment 1 after 6 mo of storage in the two 1.6 °C treatments (Table 4); viability in the Ziploc (1.6 °C) treatment was significantly higher than that in the perforated Skilcraft bag (4.0 °C) treatment after 6 mo (82% versus 48%). In Experiment 2, percentage viability of acorns that did not germinate in storage ranged from 30 to 50% at 7 mo and from 7 to 30% at 13 mo. At 19 and 25 mo, we observed no viable, nongerminated acorns.

Among the acorns that germinated during 12- and 13-mo storage treatments, 34% of germinated acorns had a radicle less than 1 cm (0.4 in) long, and 86% of germinated acorns had a radicle less than 3 cm (1.2 in) long. Of the acorns that germinated during 19- and 25-mo storage treatments, 95% of the acorns that were planted in pots grew to seedlings (Figure 3).

DISCUSSION

Overall, the percentage of acorns germinating during storage was high, averaging 63% across all treatments after the 12- and 13-mo storage durations. The in-storage germination percentages in Experiment 2 were somewhat higher than in Experiment 1 (71 versus 52%), perhaps owing in part to the additional month of pre-treatment storage at 4.0 °C in Experiment 2 or to the inclusion of the Rock Creek seed source that had an exceptionally high percentage of in-storage germination. We found, however, that the acorns that germinated during storage were still viable after they were removed from storage.

TABLE 3

Total germination (sum percentage of acorns that germinated in storage and those that germinated in post-storage germination tests) for Oregon white oak acorns stored under various treatment combinations in 2 experiments.

Treatment	Months in storage [z]							
	0	*2*	*4*	*6/7*	*8*	*12/13*	*19*	*25*
	%							
Experiment 1								
Perforated 2-mil Skilcraft bag, 4.0 °C [y]	87 a	88 ab	80 ab	82 ab	75 ab	69 b	—	—
Ziploc 2.7-mil freezer bag, 1.6 °C	87 a	85 ab	70 b	91 a	74 ab	79 ab	—	—
Star*Pac, 1.6 °C	90 a	85 a	74 ab	83 ab	78 ab	80 ab	—	—
Experiment 2								
Star*Pac, 4.0 °C	97 a	—	—	85 ab	—	70 b	—	—
Star*Pac, 1.6 °C	97 a	—	—	88 ab	—	95 ab	90 ab	85 ab
Star*Pac with bleach, 1.6 °C	96 a	—	—	90 ab	—	93 ab	95 a	90 ab
Star*Pac with Captan, 1.6 °C	97 a	—	—	93 ab	—	88 ab	93 ab	77 ab

Note: Within each experiment, values accompanied by the same letter do not differ at the 95% confidence level according to Tukey's HSD test. Cells without data were storage durations not tested.

[z] Acorns in Experiment 2 were stored at 4 °C for approximately 1 additional month before treatments were initiated.
[y] 4.0 °C = 39 °F; 1.6 °C = 35 °F

Even after 19- and 25-mo storage durations, 95% of the storage-germinated acorns produced seedlings (Figure 4). This contrasts with the observations of Bonner and Vozzo (1987) who reported that stored acorns of the white oak group from the eastern US died rapidly after they germinated in storage. It is not clear whether this difference in viability is a result of species differences or storage conditions.

Germination during storage has the potential to complicate acorn handling, make sowing difficult, and increase susceptibility to fungal damage (Bonner 2003). After 12 mo of storage, most sprouted radicles in our study were less than 3 cm (1.2 in) long. The likely breakage of these radicles during subsequent handling and sowing does not preclude a productive seedling crop, however, as acorns are likely to form secondary radicles following breakage (Bonner 2003). We have observed new growth from the ends of broken Oregon white oak radicles (Devine and others 2009). Cherrybark oak (*Q. pagoda* Raf.), Shumard oak (*Q. shumardii* Buckley), blue oak (*Q. douglasii* Hook. & Arn.), and Oregon white oak acorns with germinated, but broken or damaged, radicles exhibited normal growth and survival as seedlings and had a root morphology characterized by multiple taproots (Bonner 1982; McCreary 1996; Devine and others 2009). Thus, sowing of storage-germinated acorns may be a viable option if the work is to be done manually for a manageable number of acorns.

The exceptions to the generally high in-storage germination rates found throughout this study were the 1.6 °C storage treatments in Experiment 1. In these 2 treatments, germination remained low (9 and 10%) for storage durations as long as 6 mo, although germination increased under longer storage. The combination of low temperature (1.6 °C) and sealed polyethylene bags proved effective for 6-mo storage.

Because overall acorn viability was high for all treatments and storage durations, gas-exchange rates were apparently sufficient for all bag types. The Ziploc freezer bags and Star*Pac bags did not differ from the so-called

TABLE 4

Percentage of acorns placed in storage that germinated during storage (top number in each cell) and percentage of acorns placed in storage that were ungerminated at the end of storage but still viable (lower, italicized number), for Oregon white oak acorns stored under various treatment combinations in 2 experiments.

Treatment	Months in storage [z] 2	4	6/7	8	12/13	19	25
	%						
Experiment 1							
Perforated 2-mil Skilcraft bag, 4.0 °C [y]	4 CDE *84 ab*	21 BCD *59 bcde*	34 ABC *48 cdefg*	40 AB *35 fgh*	50 A *19 h*	—	—
Ziploc 2.7-mil freezer bag, 1.6 °C	4 CDE *82 ab*	0 DE *70 abcd*	9 CDE *82 ab*	28 BC *46 efg*	52 A *27 gh*	—	—
Star*Pac, 1.6 °C	0 E *86 a*	1 DE *74 abc*	10 CDE *72 abcd*	27 BC *51 def*	54 A *25 gh*	—	—
Experiment 2							
Star*Pac, 4.0 °C	—	—	37 CD *50 ab*	—	42 BCD *30 abcd*	—	—
Star*Pac, 1.6 °C	—	—	44 D *44 a*	—	84 AB *10 cd*	90 A *0 d*	85 A *0 d*
Star*Pac with bleach, 1.6 °C	—	—	62 ABCD *30 abcd*	—	84 ABC *7 bcd*	95 A *0 cd*	90 AB *0 cd*
Star*Pac with Captan, 1.6 °C	—	—	48 ABCD *46 abc*	—	75 ABCD *15 abcd*	93 A *0 cd*	77 ABCD *0 cd*

Note: Within each experiment, during-storage germination values accompanied by the same uppercase letter do not differ, and post-storage germination test values accompanied by the same lowercase letter do not differ. Mean separation was conducted at the 95% confidence level using Tukey's HSD test.

[z] Acorns in Experiment 2 were stored at 4 °C for approximately 1 additional month before treatments were initiated.
[y] 4.0 °C = 39 °F; 1.6 °C = 35 °F

conventional approach to small-scale acorn storage (represented here by perforated Skilcraft bags) producing similar total germination percentages after 12-mo storage. This is likely because all bags were thin-walled (or also perforated); the greatest bag-wall thickness, that of Ziploc freezer bags, was only 2.7 mils, which is thin enough to allow sufficient gas exchange for stored white oak acorns to maintain viability (Bonner 2008). Bag-wall thicknesses greater than 4 mils are not recommended unless the bags remain unsealed (Rink and Williams 1984). Small quantities of acorns stored in perforated or unsealed bags, however, risk desiccation in the low-humidity environment of a refrigerator, particularly during long storage periods.

In Experiment 2, total acorn germination after 13 mo was only 2 to 9 percentage points lower than initial germination percentage in the three 1.6 °C treatments. By contrast, total germination was 27 percentage points lower than initial germination for acorns stored 13 mo at 4.0 °C. This difference is probably a result of the fact that colder temperatures slow acorns' metabolic activity. Acorns of the closely related species white oak (*Q. alba* L.) did not germinate when stored at -2.0 °C (28.4 °F); however, their viability was reduced to only 30% after 120 d in storage (Connor 2004). Alternatively, several other species from the white oak group retained relatively high levels of viability at storage temperatures between -2.0 and -1.5 °C (28.4 and 29.3 °F) (Schroeder and Walker 1987; Connor and Bonner 1999; Conner and Sowa 2002; Connor 2004). Although it remains unclear what effect subfreezing temperatures would have on viability of Oregon white oak acorns, our findings indicate that temperatures colder than 1.6 °C are necessary to reduce in-storage germination.

Pre-storage treatment with bleach and fungicide did not have a significant effect on acorn viability. Although acorns treated with Captan in Experiment 2 had a numerically lower viability after 25-mo storage (77% versus 85% for soap wash only), this value was not part of a broader trend and was not statistically different from the other treatments at 25 mo.

Figure 3. Oregon white oak seedlings can be monitored in test beds. Photo by Joseph Kraft

Figure 4. Ninety-five percent of the acorns that germinated during 19- and 25-mo storage treatments grew into seedlings when planted in pots. Photo by Warren Devine

Among the 7 seed sources, the Rock Creek acorns showed a strong tendency to germinate after less than 6 mo in storage. Several explanations are possible. First, this source was collected approximately 1 mo before the other seed sources and during that time remained in storage at 4.0 "C. Second, the earlier collection is likely the reason for the relatively high moisture content of the Rock Creek acorns (Bonner and Vozzo 1987); this high moisture content, in turn, may have influenced the likelihood of germination during storage (Connor and Bonner 1999). Third, the Rock Creek population is geographically distant from the other 6 seed sources; it is located east of the Cascade Mountains where summer temperatures are warmer, winters are colder, and annual precipitation is much lower. Oregon white oak acorns from this population are likely adapted to germinating under different conditions than those of the Puget Sound region. But because two of the Puget Sound seed sources collected on similar dates and with similar moisture contents (Scatter Creek and Weir Prairie) differed in 12-mo storage germination, it is possible that populations from the same region also differ in germination. It is not clear, however, whether these differences were a result of site-related variation in acorn maturity at the time of collection or a product of genetics.

CONCLUSIONS

While total Oregon white oak acorn viability remained uniformly high for storage durations as long as 25 mo, a substantial percentage of germination occurred during storage, except for acorns placed in storage at 1.6 °C soon after collection and stored 6 mo or less. As with other white oak species, the primary storage problem remains the suppression of germination during storage, although the storage-germinated acorns remained predominantly viable in this study. Further research is needed to assess the effects of subfreezing storage on in-storage germination and post-storage viability. Oregon white oak acorns *should* be refrigerated as soon as possible after collection and then promptly sorted, cleaned, and placed in storage at a temperature close to freezing. Either conventional, thin-walled plastic bags or specialized gas-permeable storage bags may be used to limit acorn moisture loss during storage.

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