Effects of Moisture Content and Storage Temperatures on Germination of *Quercus macrocarpa* Acorns[1]

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Abstract

Viability of bur oak *Quercus macrocarpa* Michx. acorns was determined after 6 months storage at −2°C (28°F), 1°C (34°F) and 5°C (41°F) and moisture contents of either 17%, 27%, 37% or 44%. Viability was significantly affected by moisture content with optimum germination occurring for acorns stored at 44% moisture. Optimum storage temperature was 1°C (34°F) although acorns tolerated subfreezing temperatures to −2°C (28°F) with little loss in viability. Acorn moisture content had a greater effect on viability than storage temperature. Storage for up to 6 months had no detrimental effects on germination of bur oak acorns.

Index words: Bur oak, acorn, viability, moisture content, storage, sexual propagation

Introduction

Greenhouse container production of bur oak seedlings for shelterbelt planting in Western Canada has been under investigation because of poor outplanting survival of bare root seedlings (11). The high heating requirements for greenhouse production of this species makes early March when air temperatures have moderated the most economical time to grow bur oak. This means that oak acorns must be stored for up to 6 months after collection.

Unlike seeds from gymnosperms and most small-seeded angiosperms, acorns of *Quercus* species are reportedly difficult to store (3, 5, 6, 8, 9, 14). Seed storage of most species in the white oak groups (subgenus *Erythrobalanus*) has not been recommended (6, 7) and as a result most nurseries sow acorns in the fall immediately following collection (8). Research by Suszka and Tylkowski (13) with English oak (*Quercus robur* L.) as well as by Rink and Williams (12) with white oak (*Quericus alba* L.) indicated that both species could be stored with little loss in viability. According to some researchers, viability of oak acorns was related to seed moisture content (3, 4, 8). Jones (7) suggested that for optimum germination, the moisture content of white oak acorns must not drop below 30%. Similarly, optimum germination of bur oak occurred when acorn moisture content was greater than 40% (10). Storage temperature has not been thoroughly investigated however Bonner (3) suggested that acorns be stored at 1° (34°F) to 2°C (36°F) and that storage at temperatures higher than 2°C (36°F) caused prolific sprouting whereas subfreezing temperatures killed acorns. In this study four moisture contents and three storage temperatures were evaluated for short term storage of bur oak acorns.

Materials and Methods

Seed collections were made in October 1985 from bur oak trees located at the Prairie Farm Rehabilitation Administration Tree Nursery, Indian Head, Saskatchewan. Acorns were bulked into one lot, those with weevil holes discarded, and the remainder placed in sealed polyethylene bags for one week until treatments were initiated.

The acorns were divided into four lots. One lot consisted of nondried seed at a uniform moisture content of 44%, while the remaining three lots, destined for storage at lower moisture contents, were dried on greenhouse benches until moisture contents of 37, 27, and 17% were attained. Moisture contents, based on percent fresh weight, were determined gravimetrically after five, 10-acorn replications from each lot were dried at 105°C (221°F) for 24 hr.

The three storage temperatures evaluated were −2°, 1° and 5°C (28, 34, and 41°F). Acorns were held in sealed polyethylene bags for the 6 month storage period. Immediately prior to the start of storage, a germination test was conducted. Five, 10-acorn replications of each moisture content were sown at a 3 cm (1.2 in) depth in Spencer-Lemaire containers filled with peat moss : vermiculite (3:1 by vol). Seed was not stratified prior to sowing. After 6 months storage the germination test was repeated. Five, 10-acorn replications representing each initial moisture content and storage temperature were inspected for sprouting and then moisture content was determined. In addition, five, 10-acorn replications of each treatment were sown in containers as in the pre-storage test. Germination conditions for the pre- and post-storage tests were identical with 16 hours at 25°C (77°F) in natural sunlight supplemented by fluorescent lamps (irradiance at growing surface = 28.7 w/m^2) followed by eight hours at 20°C (68°F) in the dark; relative humidity ranged from 70 to 80%. A seed was considered to have germinated when the protruded radicle showed a positive geotropic response and the seedling emerged through the growing medium. Emergence was recorded every 3 days and continued for 60 days following sowing. Germination rate, which indicated the speed at which germination occurred, was determined by Bartlett's germination index (1) and germination capacity was the percent of seed which emerged.

The experiment was a split-plot design, with a randomized complete block arrangement of mainplot storage temperature treatments. According to design requirements, the subplot moisture content treatments were randomly located within each mainplot. Significant differences between main-

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plot and subplot treatments was determined by analysis of variance. Mean separation was according to least significant difference (LSD). Data for the randomized complete block design pre-storage data and split-plot design post-storage data were analyzed using linear regression procedures.

Results and Discussion

Germination capacity decreased with decreasing acorn moisture content prior to storage. The relationship between acorn moisture content and germination had significant ($p \leq 0.01$) quadratic and cubic components (Fig. 1). The data indicated that germination increased rapidly after about 33% moisture content.

After 6 months storage there was no evidence of sprouting at any storage temperature or acorn moisture content. Moisture content of the acorns did not change significantly during the storage period. Post-storage germination rate was significantly correlated to acorn moisture content ($R = 0.98$, $p \leq 0.01$). Acorns with the lowest moisture content had the lowest germination (Fig. 2). The effects of storage temperatures and moisture contents were significantly different ($p \leq 0.05$) for both germination capacity and germination rate. In addition, there were significant interactions between acorn moisture content and storage temperature for both parameters. Germination capacity of acorns at 44, 27 and 17% moisture content did not differ significantly ($p \leq 0.05$) when stored at −2°, 1° or 5°C (28, 34 or 41°F) while acorns at 37% moisture had significantly ($p \leq 0.05$) higher germination capacity when stored at 5°C (41°F) than at −2° (28°F) or 1°C (34°F). Regardless of storage temperature, acorns at 44% moisture content had significantly ($p \leq 0.05$) higher germination capacity than acorns at lower moisture contents. Acorns dried to 37% moisture had significantly ($p \leq 0.05$) higher germination capacity than 27 and 17% moisture content. Germination capacity and rate response curves are illustrated in Fig. 3.

Germination rates of acorns at 37, 27 and 17% moisture content did not differ significantly ($p \leq 0.05$) when stored at −2°, 1° or 5°C (28, 34 or 41°F) while acorns at 44% moisture and stored at 5°C (41°F) had a significantly ($p \leq 0.05$) lower germination rate than acorns stored at −2° (28°F) and 1°C (34°F). At −2° (28°F) and 1°C (34°F), acorns at 44% moisture had a significantly higher germination rate than acorns at 37, 27 and 17%. In addition, acorns stored at 37% had a significantly higher germination rate at all storage temperatures than acorns at 27 and 17%.

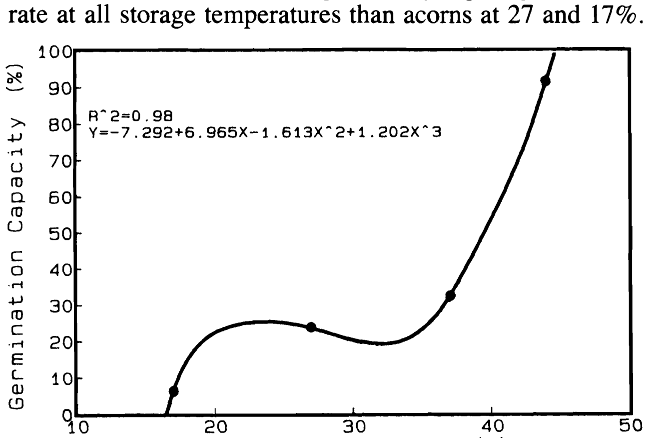

Fig. 1. The relationship between acorn moisture content and germination prior to storage.

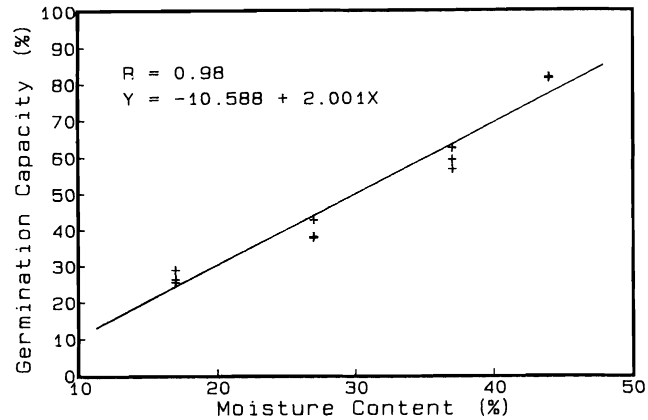

Fig. 2. The relationship between acorn moisture content and germination after 6 months storage.

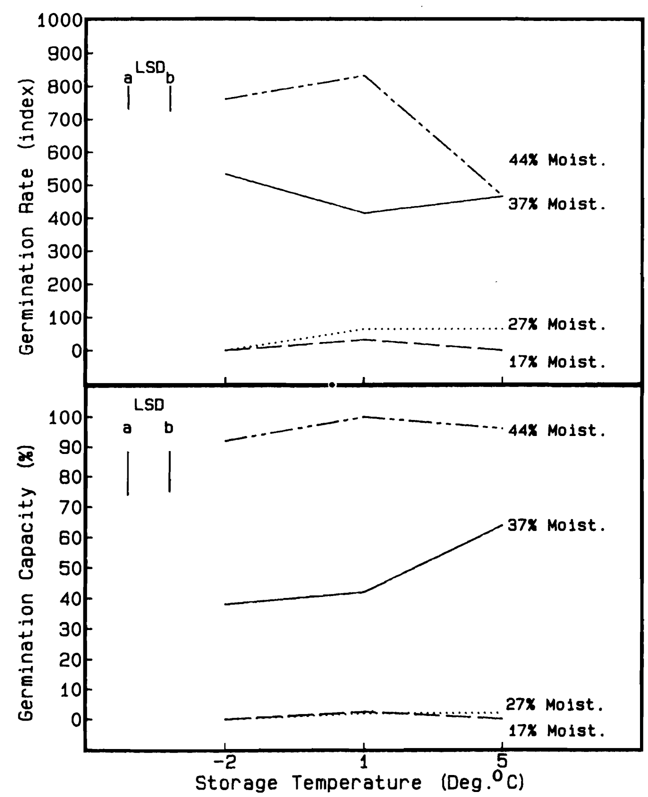

Fig. 3. Germination capacity and rate of bur oak acorns stored at four moisture contents and three temperatures. Least significant differences (LSD, .05) are shown for (a) moisture content subplots within temperature mainplots and (b) for temperature mainplots within moisture content subplots.

[1]The higher the number the earlier germination commenced.

At 5°C (41°F) storage, acorns at 44 and 37% moisture had identical germination rates.

There were significant changes in germination of stored acorns when moisture content was decreased. Reduction of moisture content below mature levels (44%) severely affected germination of bur oak acorns. Storage temperatures near or below freezing did not damage acorns or affect germination at the optimum moisture content of 44%. In fact, germination rate was significantly reduced when storage temperature increased to 5°C (41°F). The delayed germination of acorns stored at 44% moisture and 5°C (41°F) could not be explained with the available data. The maintenance of high moisture content over the storage period indicated that this phenomenon was not the result of desiccation at higher temperatures. Possibly the metabolism of the acorn was altered causing the reduction in germination rate. When pre-storage germination data were compared to pooled post-storage data there was little change in germination trends which indicated that storage of bur oak acorns for periods up to 6 months had little or no affect on acorn viability.

The relationship between high moisture content and germination of acorns of white oak species has been hypothesized by Clatterbuck and Bonner (5). They noted that carbohydrates are the predominant food reserve and comprise 80 to 90% of the acorn dry weight, and suggested that the high tissue hydration corresponding to the presence of soluble carbohydrates is suspected of triggering germination. The tolerance of bur oak acorns to freezing temperatures during storage was contrary to other reports that suggested freezing temperatures killed acorns of the white oak subgroup (2). The lack of germination during the storage period, especially at higher temperatures and moisture content, was a phenomenon not usually associated with acorns of the white oak group. These characteristics of bur oak deserve further study.

Significance to the Nursery Industry

Fall sowing is commonly recommended for the white oak group (8). However, based on these results, bur oak acorns can be stored for up to 6 months at near freezing temperatures with little loss in germination capacity if acorn moisture content is maintained at mature levels (44%). Overwinter storage of acorns facilitates the practice of late winter container growing of bur oak.

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