

EFFECT OF SEED POSITION AND MEDIA ON GERMINATION OF BLACK WALNUT AND NORTHERN RED OAK: IMPLICATIONS FOR NURSERY PRODUCTION AND DIRECT SEEDING

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ABSTRACT—Germination of black walnut (*Juglans nigra* L.) and northern red oak (*Quercus rubra* L.) prior to sowing into containers or bareroot nursery beds can help maintain desired crop density and reduce nursery costs. Recommended techniques for germination of black walnut are labor intensive and require that walnuts be completely covered with growing media, periodically removed, and rinsed to identify germination prior to excessive elongation of the radicle. The purpose of this study was to determine if immersing 50% of a walnut into the soil such that the germinating radicle could be readily observed—a successful germination technique for northern red oak acorns—was also viable for germinating walnuts. The effect of media type on germination was also investigated. Percent germination was not influenced by seed position; however, fewer black walnuts germinated in vermiculite than in a soil mix. These findings may benefit research projects, small-scale nursery production, and direct-seeding operations.

INTRODUCTION

Throughout the Central Hardwood Forest Region, production of fine hardwood trees is an important component of the forest industry. In Indiana, landowners typically plant for timber production, creation of wildlife habitats, and to leave a legacy for future generations (Ross-Davis and others *in press*). Northern red oak (*Quercus rubra* L.) and black walnut (*Juglans nigra* L.) have proven to be valuable species for timber production and wildlife utilization, making them among the most abundantly planted species in Indiana (Jacobs and others 2004).

To produce tree seedlings, seeds are collected, stored and stratified (if necessary), and sown into containers, nursery beds, or the field. Standardized nursery practices involve covering the seed with soil immediately after sowing to prevent desiccation (Landis 1990, Auchmoody and others 1994) and, in the case of bareroot stocktypes, to limit seed predation (USDA Forest Service 1948, Auchmoody and others 1994, Kujawski and Davis 2001). Procurement of hardwood tree seed is an expensive undertaking, therefore demanding increased seed viability to ensure uniform crop production

and efficient use of nursery growing space. While various tests can be used to ensure that only viable seeds are planted (e.g., float-test and x-ray), germination cannot be guaranteed. For example, viable seed sown under insufficient moisture or temperature conditions may not germinate. Additionally, these tests are expensive and time consuming, limiting their value on an operational scale for many nurseries.

Germinating seed prior to sowing could reduce nursery production costs for bareroot and container grown seedlings and increase the success of direct seeding operations. Bareroot seedling production methods consist of sowing seed in nursery beds immediately after collection or removal from storage. Germination of seed prior to sowing improves the likelihood of maintaining constant density in the nursery bed. In containerized seedling production, the number of containers and the amount of soil media needed are directly dependent upon the number of containers sown. Therefore, an increase in the percentage of cells containing successfully germinated seedlings would reduce production costs. The use of pre-germinated seed would help to ensure that in each container is a viable seed. Direct-seeding operations typically

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Citation for proceedings: Michler, C.H.; Pijut, P.M.; Van Sambeek, J.W.; Coggeshall, M.V.; Seifert, J.; Woeste, K.; Overton, R.; Ponder, F., Jr., eds. 2004. Black walnut in a new century, proceedings of the 6th Walnut Council research symposium; 2004 July 25-28; Lafayette, IN. Gen. Tech. Rep. NC-243. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Research Station. 188 p.

broadcast large volumes of seed across the area designated for reforestation (Johnson 1981, 1983). Drawbacks associated with the direct seeding of black walnut include unpredictable germination and seed predation (Van Sambeek 2004). Germination of seed prior to sowing resulted in successful plantation establishment with uniform spacing and survival rates > 90% (Jacobs and Severeid 2004). While pre-germination may not be operationally feasible for many nurseries, it could serve to decrease variation due to germination rate in research projects.

An experiment recently conducted by the Hardwood Tree Improvement and Regeneration Center called for the germination of approximately 10,000 black walnut seeds (Jacobs and others *in press*). To achieve the required number of germinated seeds, walnuts were sown into flats and covered with growing media, following the recommended procedure for *Juglans* spp. of covering nuts to a depth of up to 7.62 cm (USDA Forest Service 1948, Kujawski and Davis 2001, Reid 1998). Seeds were examined regularly for germination, and those that germinated were removed from the flats and stored under moist towels at 2° C until target quantities of germinated walnuts were available. Minimal development of the radicle of germinated seeds was important to maintain uniform seedling development across the project (Fig. 1). Therefore, early detection was vital and extensive time and labor was invested for frequent assessment of seed status.

These intensive requirements raised questions about the feasibility of alternative germination methods. Successful germination of northern red oak results from 50% immersion of acorns into the soil (Fig. 2) (Davis 2003), despite recommendations that seeds be completely covered by soil (USDA Forest Service 1948, Kujawski and Davis 2001). Since moisture conditions can be readily controlled through a combination of timers and mist-irrigation systems, it was hypothesized that germination of black walnuts and northern red oak acorns



Figure 1.—Minimal development of germinated black walnut.



Figure 2.—Northern red oak germinating 50% immersed in soil.

would be similar whether they were placed 50% immersed in the growing media or fully covered by media. Furthermore, given that different media have different moisture holding capacities, a soil media and coarse vermiculite were both selected as variables. Given the ease with which germination could be monitored, successful germination of walnuts and acorns only 50% immersed in the growing media would greatly decrease the traditional labor-intensive process of monitoring germination. The objective of this study was to determine if northern red oak and black walnut seed germination was influenced by seed position or media type.

Materials and Methods

Northern red oak and black walnut were chosen as the trial species based on their importance in the Central Hardwood Forest Region. To reduce genetic variability, all walnuts and acorns used in this study came from a single respective tree. All seeds were collected in autumn 2002. The walnut hulls were removed prior to storage; prior to sowing, acorns were floated for 48 hours with all floating seeds removed.

Seeds were sown April 21, 2003 into individual 75 cm³ pots (5 cm × 5 cm × 5 cm). Each pot contained either coarse grade vermiculite (Strong-Lite® Sunshine®, Sungro™ Horticulture, Pine Bluff, AR) or Scott's 366-P ScottsCoir™ growing medium (The Scotts Company, Marysville, OH). In their respective growing media, walnuts and acorns were randomly assigned to one of two treatments: (1) 50% immersion in the media, or (2) submersion 1 cm below the surface. To maximize the likelihood of germination, acorns were sown on their side (Trencia 1996) and walnuts were sown with their cleavage line perpendicular to the soil surface (Ciccarese 1995). The pots were then watered to saturation and placed in a mist propagation bench

in the Horticulture and Landscape Architecture Plant Growth Facility at Purdue University. Pots were misted every 10 minutes for 10 second durations for 24 hours per day. After 6 weeks, total germination was recorded for each treatment.

The study was established as a completely randomized design (2×2 factorial [position \times media]). For each species, analysis of variance was used to identify differences in germination percent by treatment. The level of significance was set at $\alpha = 0.10$. SAS® (SAS Institute, Cary, NC) was used for all data analyses.

RESULTS AND DISCUSSION

Neither seed position ($p = 0.9756$) nor media ($p = 0.9759$) had a significant effect on the percent germination of northern red oak acorns (Fig. 3). Position (50% immersed or completely covered by 1 cm of media) did not significantly affect the percent germination of walnuts ($p = 0.7151$). Media had a significant effect ($p = 0.0504$) on the germination percent of walnuts (Fig. 3). It is possible that fewer walnuts germinated in the vermiculite media due to the higher porosity of coarse vermiculite. While coarse vermiculite was used for this study, different grades of vermiculite (i.e., fine or medium textured) may be more suitable to walnut germination given differences in internal porosity (Landis 1990). There was no significant interaction between seed position and media type for northern red oak ($p = 0.9763$) or black walnut ($p = 0.8014$).

Seed position did not influence the germination of black walnut or northern red oak acorns. These

findings concur with those reported for Persian walnut (*Juglans regia* L.) (Ciccarese 1995). When the germination of walnuts and acorns prior to transplanting is necessary, this method, compared to covering with soil, will reduce the time needed to identify and collect germinants.

The concept of using pre-germinated seed is not new. DeVelice and Buchanan (1978) recommended investigation into the use of pre-germinated ponderosa pine (*Pinus ponderosa* Laws.) as a means of increasing the likelihood of successful plantation establishment in New Mexico. Germination of seed prior to sowing containerized crops has also proven beneficial in nursery production in South Africa (South and Young 1995). The authors found this method ensures that between 98 and 99% of container cells are filled, and recommend the use of this method in North American nurseries. Adoption of this system in containerized seedling production would likely increase seed use efficiency and crop consistency, decreasing the space needed to produce a crop and costs associated with thinning and transplanting seedlings.

Advantages could also be attained in bareroot seedling production. Since seedling density influences height, root-collar diameter, and dry mass (Tomlinson and others 1996), as well as the number of first-order lateral roots (Schultz and Thompson 1996), using germinated seed to maintain consistent density may assist in producing more uniform seedlings. Black walnut seedlings grown at lower densities were more likely to produce more first-order lateral roots, which increased seedling survival and growth after outplanting (Schultz and Thompson 1996). Therefore, using pre-germinated seed would

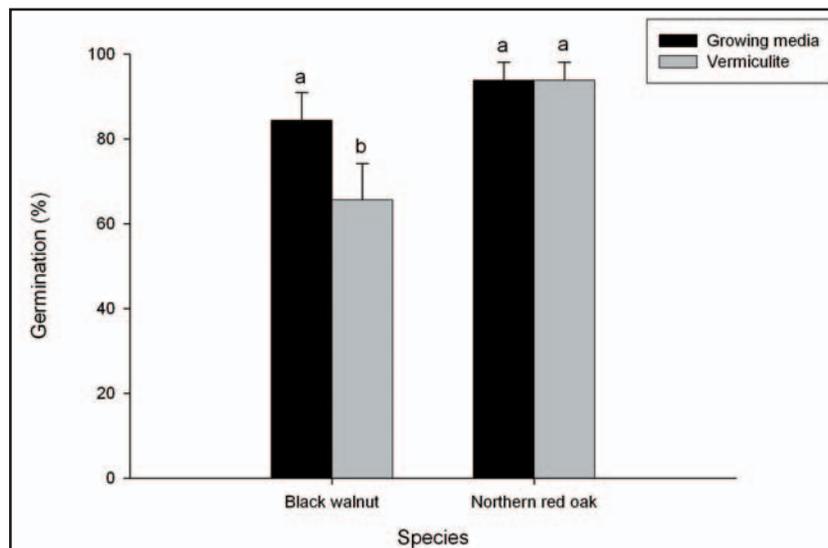


Figure 3.—Percent germination of black walnuts and northern red oak acorns for two media types. Different letters represent differences within species significant at $\alpha = 0.10$.

increase a grower's control over seedling bed density, which could improve outplanting survival and growth.

Successful plantation establishment can be achieved via direct-seeding (Johnson 1981, 1983; Wittwer 1991). Direct-seeded Nuttall oak (*Quercus nuttallii* Palmer) sown at approximately 8,000 acorns per ha yielded 5,657 trees per ha after 10 years (Johnson 1981). Mullins and others (1998) found that there was no significant difference in height or diameter of bareroot, containerized or direct-seeded (not pre-germinated) cherrybark oak (*Quercus falcata* Michx. var. *falcata*) seedlings 5 years after planting.

While attempts to direct-seed black walnut have yielded mixed results (Robison and others 1997), the potential exists to do so successfully (Schavilje 1941, Davidson 1980). Lack of success has been attributed to poor germination and growing conditions in the field (Robison and others 1997). Germination prior to seeding, however, may act to improve the success rate of direct-seeding attempts, given successful plantation establishment with direct-sown pre-germinated seed of northern red oak, black walnut, and American chestnut [*Castanea dentata* (Marsh.) Borkh.] (Jacobs and Severeid 2004). Further research is needed to identify those site conditions and tending requirements that will ensure successful establishment, as well as determining the economic and ecological costs and benefits of this method for reforestation. Additionally, research into herbicides that are suitable for use with direct seeding (Willoughby and others 2003) will lead to improved flexibility in field experimentation.

Direct seeding as a means of plantation establishment could reduce those stresses related to planting. The loss of fine roots of hardwood species during wrenching may retard seedling development. In addition to potential benefits realized in seedling establishment, the cost of transporting seed is lower than that of seedlings (Van Sambeek 2004). Bullard and others (1992) found that on old-field sites in the southern United States the cost of direct seeding oak was approximately 1/3 of those of planting seedlings and that given proper stand management there would be no benefit of planting seedlings over direct seeding.

The potential to use direct seeding of pre-germinated seed as an effective means of enhancing existing plantations should not be disregarded. On

non-industrial private forestland plantations in Indiana, survival of hardwood seedlings at age 5 has been estimated at approximately 65% (Jacobs and others 2004). Many landowners establish plantations at a desired density. To maintain the desired stocking with seedlings would require hand planting to fill in where mortality occurred, which can be strenuous and may limit seedling vigor (Jacobs and others 2004, Russell Jr. and others 1998). Germinant sowing to replace dead seedlings may be a viable means of maintaining stocking at a desired level without having to purchase and plant additional seedlings.

CONCLUSION

Pre-germination of acorns and walnuts may be beneficial by increasing uniformity of research projects and small-scale nursery culture and direct-seeding operations. The results of this study emphasize the need to understand the influence of different media types on the production of hardwood seedlings. Identification of media that maximizes the likelihood of black walnut germination will be beneficial to improving walnut production efficiency. Easy detection of walnut and acorn germination can be achieved with sowing seed 50% immersed into soil. This process can save money, time, labor, and materials without losses associated with non-germinated seeds. As consistent seedling density increases the uniformity of a crop and maximizes the use of growing space, crop production efficiency would benefit from this approach. Planting operations that choose to employ the direct-seeding method would also benefit from pre-germinating seed, as reduced sowing density would be needed to achieve the desired spacing. Further trials with a larger sample size and additional treatments may be warranted to affirm our results and identify procedures that further enhance germination success.

ACKNOWLEDGMENTS

We would like to thank Jim McKenna (Hardwood Tree Improvement and Regeneration Center), Rob Eddy (Horticulture and Landscape Architecture Plant Growth Facility at Purdue University), and Patricio Alzugaray for their assistance with seed collection and space management. Marcus Selig, Ron Overton, and Amy Ross-Davis provided assistance with the preparation of this manuscript.

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