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DORMANCY AND ROOT REGENERATION OF BLACK WALNUT SEEDLINGS: EFFECTS OF CHILLING

W. J. Rietveld, *Research Plant Physiologist, Carbondale, Illinois,*
and **Robert D. Williams,** *Principal Silviculturist, Bedford, Indiana*

ABSTRACT.—New root and shoot growth of black walnut seedlings were strongly dependent on the amount of time they were kept at a cold temperature. Physiological dormancy ended after approximately 3,100 hours at 3C, but growth responses continued to increase after 4,600 hours. Root regeneration was strongly correlated with shoot growth.

OXFORD: 181.36:161.9:176.1. KEY WORDS: *Juglans nigra*, cold storage, root regeneration potential.

Absorption of water and nutrients by black walnut (*Juglans nigra* L.) seedlings is primarily a function of new roots (Finn 1966). Slow regeneration of roots may be a possible cause for the slow top growth of walnut seedlings during the first growing season after they are transplanted. Root regeneration potential (RRP), a measure of seedling physiological quality, is the capacity of seedlings to initiate and elongate new roots rapidly after transplanting. High RRP has already been shown to be important to survival and subsequent growth for other species (Stone and Schubert 1959, Stone *et al.* 1962). This paper reports the seasonal pattern of RRP of freshly lifted and stored black walnut seedlings and its relation to chilling.

METHODS

Eleven liftings of 1-0 black walnut seedlings were made between October 6, 1976, and April 25, 1977, from the Vallonia Forest Nursery, near Brownstown, Indiana. Each lot of seedlings was graded to minimum stem caliper of 0.7 cm, root pruned to 22.0 cm, and then shipped to Carbondale, Illinois. Twelve seedlings were potted at each of the following dates: immediately, December 8, March 10, and May 12. The seedlings that were not potted immediately were stored at 3C until the time they were potted.

Root regeneration potential was determined by a method similar to that of Stone and Schubert (1959). Potted seedlings were placed in a greenhouse for 4 weeks. Air temperature in the greenhouse varied seasonally (minimum 16C), a photoperiod of 16 hours was maintained by supplemental lighting, and soil temperature was maintained at 24C.[1] At the end of the 4 weeks, the seedlings were unpotted and total shoot elongation, stem caliper 2.5 cm above root collar, ovendry weight of all new roots, and ovendry weight of the total root system were determined for each seedling. The length-of-storage-treatments were compared for significant differences by analysis of covariance—total root dry weight was the covariable for root growth response and stem caliper was the covariable for shoot growth response.

RESULTS AND DISCUSSION

All seedlings had to be subjected to cold temperatures for a minimum amount of time before any appreciable growth response appeared in RRP tests (figs. 1 and 2). During physiological dormancy, seedlings that were potted immediately could not be forced to grow during the 4 weeks in the greenhouse. In late February, an abrupt increase in growth response appeared in the seedlings that were potted immediately (fig. 1). Total shoot elongation and ovendry weight of new roots steadily increased with successive liftings during the early spring, and continued to increase beyond the time of flushing at the nursery. Seedlings lifted on April 25 had as much as 10 cm of new shoot growth at the time of lifting, but no new root growth. Existing new shoots died back during the RRP test but regrowth of shoots and regeneration of roots surpassed that of all previous lifting dates.[2] Thus, no peak in RRP was found, although it must have been imminent.

The pattern of response in stored seedlings was similar to that for seedlings overwintering in the nursery bed (fig. 2). Seedlings lifted prior to November 1 did not store well. The increase in root growth response was barely evident on March 10 for seedlings lifted on November 1, but an abrupt increase began

[1] *Reported to be near optimum by Larson (1970).*

[2] *Note that this response occurred under favorable greenhouse conditions. In a field transplanting test, seedlings lifted after flushing grew poorly.*

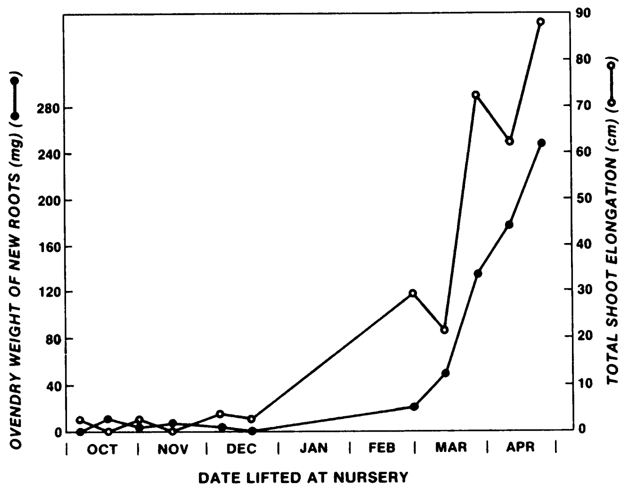

Figure 1.—*Total shoot elongation and ovendry weight of new roots for freshly lifted seedlings measured at the end of 4 weeks under forcing conditions in a greenhouse. The plotted values are the covariance-adjusted means of 12 seedlings.*

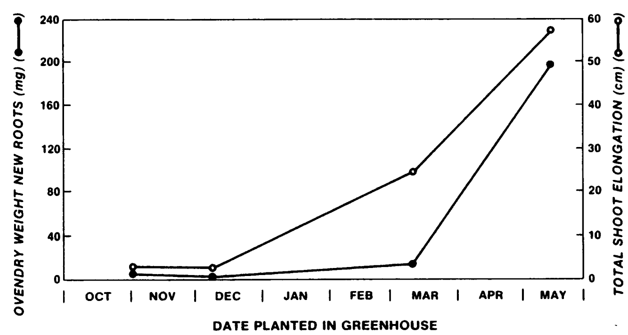

Figure 2.—*Total shoot elongation and ovendry weight of new roots for stored seedlings, measured at the end of 4 weeks after replanting. Seedlings were lifted on November 1 and then replanted on November 1, December 8, March 10, and May 12. Plotted values are the covariance-adjusted means of 12 seedlings.*

later in March, which is similar to the response for seedlings that overwintered in the nursery. The pattern of RRP for black walnut seedlings in cold storage is similar to that reported for northern red oak (Farmer 1975), pin oak and scarlet oak (Lee *et al.* 1974), and sugar maple and white ash (Webb 1977).

Seedlings that overwintered outside ended physiological dormancy about two weeks earlier than the stored seedlings, and had consistently more top and root growth in subsequent RRP tests. The winter of 1976-1977 was abnormally cold, so outside seedlings were exposed to many more degree-hours of cold temperatures than stored seedlings. The slower rate of growth resumption of stored seedlings may be due to maintenance of deeper imposed dormancy in storage—the outside seedlings were exposed to warm, sunny weather beginning in late February.

Both ovendry weight of new roots and total shoot elongation were strongly correlated with chilling time, $r=+0.82$ ($P\leq 0.05$) and $+0.90$ ($P\leq 0.01$), respectively. Seedlings lifted on November 1 and stored until March 10 had been stored at 3C for 3,100 hours, excluding exposure to cool temperatures in the nursery bed prior to November 1. The longer these seedlings remained in cold storage, the more rapidly they resumed growth and the greater the growth response during the 4-week test period. By May 12, after 4,600 hours at 3C, the peak response had not yet been reached.

In the RRP tests, root growth was strongly correlated with shoot growth ($r=+0.95$, $P\leq 0.00001$); root regeneration increased with the degree of renewed shoot elongation. The major increase in RRP coincided with active shoot growth. However, the data do not depict which process began first.

Root regeneration for seedlings lifted on November 1 and potted on May 12 (198 mg) was lower than that for seedlings lifted and potted on April 25 (249 mg). This suggests that prolonged storage lowered the RRP and/or delayed the peak response.

Overwinter cold storage of fall-lifted black walnut seedlings offers a method of supplying planting stock in physiological condition conducive to resuming rapid growth as early as needed in the spring. Seedlings lifted when dormant and properly stored can be kept without any apparent detrimental effects at least until mid-May, which is normally beyond the time walnut seedlings are planted in the Central States.

Large, 1-0 black walnut stock, which has been kept under cold conditions a certain length of time and then transferred to favorable growing conditions, has the physiological capability for quickly growing new roots and vigorous new shoots. This study demonstrated that extended cold storage enhanced the rate at which growth of black walnut seedlings was resumed after transfer to environmental conditions favorable for growth. Future research should consider methods to accelerate chilling or enhance the chilling effect so that planting stock with peak RRP is available at planting time.

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