

PHYSIOLOGY AND SILVICULTURE OF BLACK WALNUT  
FOR COMBINED TIMBER AND NUT PRODUCTION

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Abstract.--Research literature was reviewed for evidence supporting the management of black walnut plantations for combined timber and nut production. The silviculture of the species is discussed in relation to dual cropping. Stimulation and phenology of flowering and fruiting are reviewed.

Additional keywords : Diameter growth, flowering, phenology, Juglans nigra.

Walnut growers face the same economic vagaries as other businessmen. The recent surges in the cost of capital have made standard economic forecasts obsolete. Current inflation interest rates may make plantation establishment costs prohibitive when projected over the length of walnut rotations. Nut crops could provide one source of early income to offset such costs (Kincaid and Kurtz 1981).

Industries marketing nut meats and shells would like a more regular yearly volume of nuts, although walnut is considered a fairly consistent bearer (Wylie 1966). Managers of seed orchards also need methods for enhancing nut production if they are to annually supply nurseries with genetically improved seed.

Evidence is presented showing that walnut can be managed for timber and improved nut yields.

MANAGEMENT STRATEGIES FOR TIMBER AND NUTS

Maximizing timber yield conflicts with maximizing nut yields. Maximizing production of quality timber requires greater stem pruning and closer spacing of trees to favor a longer branch-free bole, while increasing nut yield involves growing trees at a wider spacing to favor larger tree crowns. Optimizing both nut and timber production involves compromises in spacing as well as in timing and extent of pruning (Schlesinger and Funk 1977).

Initial tree spacing in plantations intended for combined nut and timber production is recommended to be 15 to 20 feet square compared to 10 to 12 feet square for timber alone. Planting trees at a close spacing provides more opportunity for selection of superior crop trees. It also necessitates an earlier thinning (Schlesinger and Funk 1977, Funk et al. 1978).

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A criterion for determining the necessity and timing of thinning is crown competition factor (CCF). For nut production, the CCF should not exceed 90. A CCF of 90 means that the plantation will have to be thinned when the total crown area covers 90 percent of the plantation's land surface (Schlesinger and Funk 1977). The plantation may have to be thinned three or more times during a rotation. For example, in simulating an 80-year rotation, Foster and Kung (1980) proposed thinning a plantation six times. With a 20-foot-square spacing, the first thinning (around age 20) would be after the trees have begun flowering and fruiting. Crop trees could be selected on the basis of seed production, seed quality, and stem form.

Lateral pruning should begin when the trees are 10 to 15 feet tall (approximately age 5) and should be continued in stages until more than 9 feet of clear stemwood is obtained on every crop tree. The length of clear stem should not exceed 50 to 60 percent of total tree height. Only crop trees need to be pruned. Corrective pruning will probably not be necessary because trees with poor form will be removed during thinnings (Schlesinger, in press).

No research data are available on combined nut and timber production from walnut plantations. Using simulation techniques, Foster and Kung (1980) compared the economic efficiency of managing walnut plantations for nut and timber production versus managing for timber alone. They found that managing for combined nut and timber production was more profitable than managing for timber alone, as long as the annual compound interest rate exceeded 6 3/4 percent and rotations were longer than 40 years. Similar conclusions have been made by Wylie (1966), Callahan and Smith (1974), Garrett and Kurtz (1980), and Kincaid and Kurtz (1981) using different economic and tree growth assumptions.

Most projections for diameter growth assume it is a linear function of age with an average annual increment of 0.33 inch/year (Naughton 1970), 0.33 to 0.5 inch/year (Garrett and Kurtz 1980), or up to 0.56 inch/year (Wylie 1966). Projections for nut yields as a linear function of diameter at breast height for open grown trees are illustrated in figure 1 (Foster and Kung 1980, Garrett and Kurtz 1980).

One concern sometimes raised about combined timber and nut production is that potential tree growth may be diverted into a nut crop, possibly resulting in smaller trees. For apple trees (8 to 9 inches d.b.h.) the stem cross sectional area lost due to fruit production is approximately 0.005 square inch per pound of fruit (Webster and Brown 1980). Because no such walnut data are available, it will be assumed that the reduction in walnut growth due to fruiting is similar to that of apples. According to Foster and Kung's projection (fig. 1), an 80-year-old walnut with an average annual diameter growth rate of 0.33 inch/year should produce about 3,100 pounds of air dried, hulled nuts during its lifetime. This equals about 11,600 pounds of unhulled nuts (Funk and Polak 1979). Lifetime nut production will reduce potential stem diameter from 27.4 to 26 inches. This reduction equals 4 or 5 years of growth or about 18 board feet in the 8-foot veneer log. The value of the nut crop at current prices substantially exceeds the value of lost diameter growth for average grade walnut veneer logs. Shortening the rotation length can reduce both nut production and its potential effect on diameter growth.

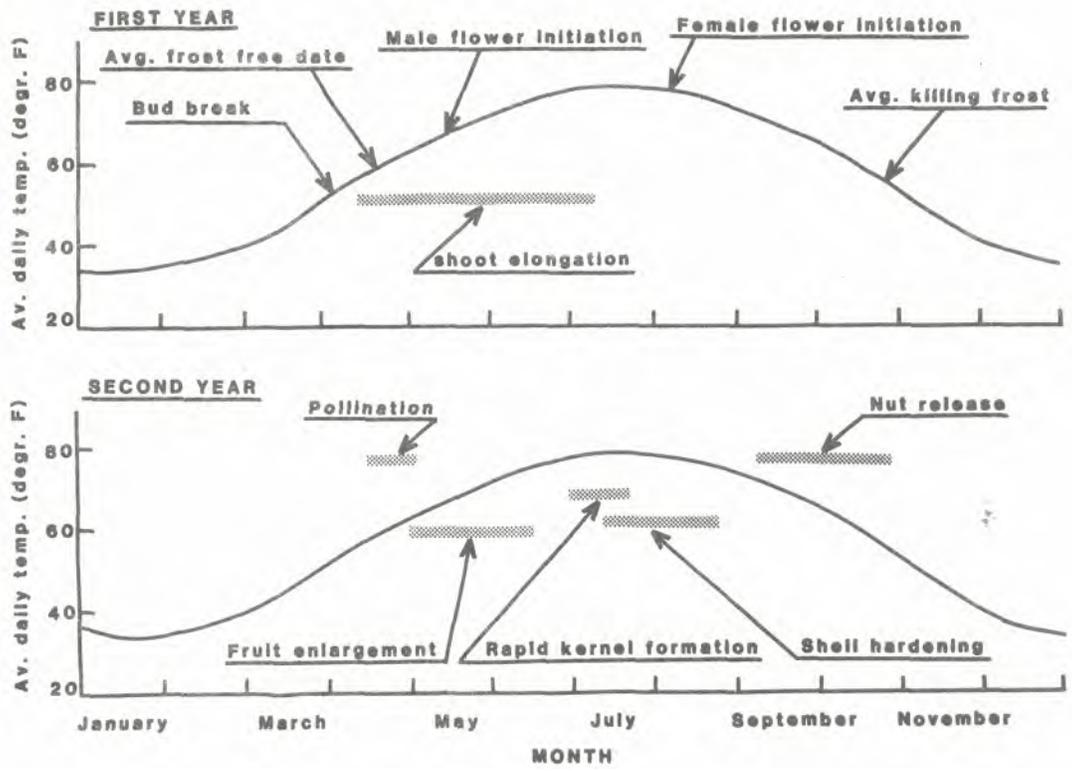


Figure 2.--Sequence of flower development, pollination, and nut maturation for black walnut in southern Illinois.

Walnuts bear separate male and female flowers on the same tree. Self-pollination is unlikely, however, because flowers of different sexes normally mature at different times; female flowers most often precede the males. However, spring floral development is definitely temperature dependent and warm temperatures at the time of flowering tend to increase the overlap between male and female flower maturation (Masters 1974).

Male flowers are found on wood grown in the previous season; they are initiated in vegetative buds during the period of rapid shoot elongation early in the growing season of the previous year. Female flowers are found at the tip of the current growing shoot, developing in dormant buds set after completion of the previous year's growth (fig. 2) (Ramina 1969, Masters 1974, Funk 1978).

Several factors influence flowering abundance. All flowers are essentially borne on the crown surface. Any cultural practices increasing the crown surface area, or number of new branches, will increase the number of potential flowering sites. In English walnut the number of female flowers increases as growth is increased (Link 1961). Likewise, increased nut yields in black walnut in response to fertilization (Ponder 1979) and weed control (Holt and Voeller 1973) may be related to improved vigor resulting in more branches and branch growth and consequently more flower production.

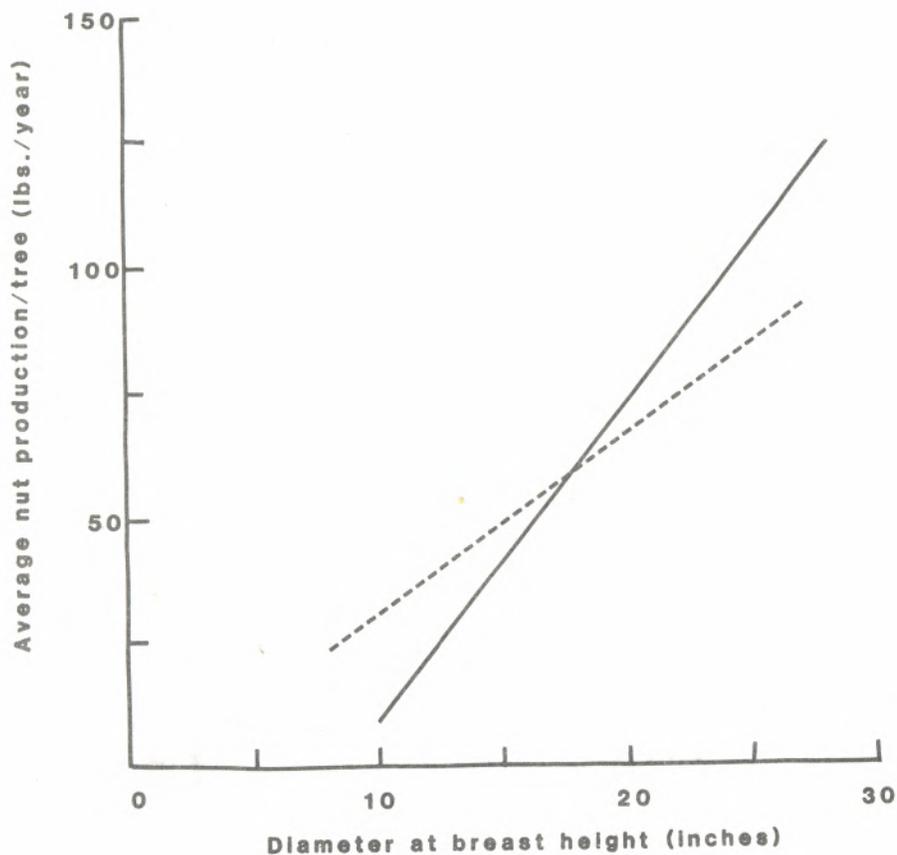


Figure 1.--Projections of average nut production by different diameter walnut trees. Solid line is for air-dried weight after Foster and Kung (1980); dashed line for freshly hulled weight after Garrett and Kurtz (1980).

Management guidelines are now available for improving diameter growth of black walnut on marginal sites (Schlesinger and Funk 1977). But what little information is available about improving nut yields has not been tested. Before we can reasonably expect to manipulate stands to improve nut yields, we must understand the physiology of flowering and fruiting for walnut. Most research on flowering and fruiting in Juglandaceae has been with English walnut and pecan, but it is assumed that much of this information also applies to black walnut.

#### FLOWERING BIOLOGY

Black walnut normally begins flowering about mid-April in the southern part of the range and mid-June in the northern part of the range, although within individual stands trees may vary by as much as a month in flowering dates (Masters 1974, McDaniel 1956). Flower development and leafing out occur at approximately the same time, early enough for possible damage by late spring frosts (fig. 2). Pollination and fertilization normally occur a few weeks after the mean frost-free date and are less likely to be affected by late spring frosts.

Late spring frosts often reduce the number of flowers reaching maturity. Compared with clean cultivation, maintenance of leguminous or grass covers in walnut plantations may delay bud break by as much as 6 to 12 days, thereby decreasing the probability of damage to new growth and flowers (Wolstenholme 1970). Overtree irrigation in the spring will also delay bud break and flowering from 5 to 6 days (Beineke and Hunley 1979).

Little research has been done on the use of chemical sprays to alter new shoot growth and subsequent flower production. Marth and Mitchell (1961) found that gibberellin treatments promoted walnut shoot elongation. Foliar spray application may increase flower production through improved branch growth. Langrova and Sladky (1971) found that auxin-containing sprays applied to English walnut when male flowers were forming decreased the number of catkins formed the following year; anti-auxin sprays applied after male flowers formed increased the number of catkins, many of which contained female flowers. The formation of male and female flowers is apparently controlled by the interaction of gibberellins, auxins, and growth inhibitors within the developing shoots (Sladky 1974). Further research is needed on cultural and chemical methods to stimulate flower formation and nut development.

#### FRUITING BIOLOGY

Fertilization occurs within 2 to 5 days of pollination, followed by a period of rapid expansion of the fruit during the next 5 to 6 weeks (fig. 2). Fruits increase in weight substantially before entering the shell-hardening stage in early July, although increases in size are not noticeable at this time. During the latter part of the shell-hardening stage (late July), the embryo and cotyledons begin to enlarge rapidly, incorporating most of the previously deposited endosperm. The kernel, composed of the embryo and cotyledons, usually does not develop until 4 to 5 weeks before the nuts are mature. By late August, some nuts can germinate after stratification. Most nuts, however, continue to increase in dry weight and do not drop from the tree until shortly after leaf fall in late September or early October.

Once the nutlets are formed, nutlet loss is usually due to disease or insect infestations. Blair and Kearby (1979) found that more than 50 percent of the potential nut crop in Missouri walnut plantations was destroyed by the walnut curculio. Epidemics of walnut anthracnose early in the growing season can cause significant nutlet losses; later or less severe disease outbreaks lead to poor nut filling and darkened kernels called ambers (Funk 1979).

Summer droughts can also lead to poor filling of the kernels and may also delay seed maturity (Batchelor *et al.* 1945, Crane 1949). Jones (1975) found that June, July, and August rainfall is an important variable in predicting annual nut crops in southwest Missouri. Irrigation during August and September may be important for high nut yields, because these months often include long dry spells.

Early fall frosts can injure new growth before it is completely lignified, preventing complete nut development and causing undesirable shrivel (Funk 1979). This frost danger is especially pertinent because recommendations for collecting seed 200 miles south of the planting site for greater timber production may result in immature nut crops (Sparks 1981). This problem may possibly be overcome by chemical treatment. In English walnuts, fall spraying with ethephon produces a mature nut crop 1 to 3 weeks sooner, and the sprayed trees produce higher quality nuts than the unsprayed trees (Martin 1971, Sibbett *et al.* 1974). Another alternative may be underplanting with leguminous winter annuals to accelerate tree dormancy (Auchter and Knapp 1937).

The minimum seed-bearing age for commercial quantities of nuts is about 12 years, although open-grown trees produce some seeds as early as 4 years after outplanting (Schlesinger and Funk 1977). The biggest challenge in managing walnut for timber and nut production is to maintain regular annual yields. On open-grown trees, nut crops are produced most commonly in an alternate-year cycle; some trees bear annually, others bear in 1 or 2 years out of 3, and many bear with no regular pattern at all (Zarger *et al.* 1969). Alternate bearing is characteristic of most fruit trees with late-season fruit maturation and is related to the carbohydrate concentration in the plant (Sparks 1979). Late-season kernel development makes a high demand on available carbohydrates and stored reserves when the new female flowers are forming. Increasing the leaf area per unit of fruit may decrease the alternate bearing tendency (Sparks 1979). Before thinning plantations, the manager may be able to identify those trees with good form that are persistent bearers or trees that produce crops during "off" years. Wylie (1966) suggested annually spot-painting trees that have above-average nut yields for a period of 5 to 10 years before thinning to facilitate crop/tree selection.

Nut quality should also be considered when selecting trees for yields. Kernel percentage, the dry weight of kernel as a percent of the dry weight of the entire nut, is the key factor in nut quality and should be more than 20 percent (Funk 1979). Such nuts can be expected to command a higher price (Garrett and Kurtz 1980).

#### CONCLUSIONS

Managing for nuts and timber requires a lower level of stocking than for timber alone to ensure rapid growth of large-crowned trees. The landowner must also prune trees to a minimum clear height of 9 feet and select for higher nut yielding trees before the last precommercial thinning.

Managers of seed orchards must select trees for rapid growth and nut production to provide landowners with the desired types. Also, they may have to select for late bud break and use techniques like overtree irrigation and herbaceous cover crops to delay bud break and flowering. Late-summer irrigation may be needed to ensure proper kernel development, and chemical ripeners may be used to mature nuts.

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