Genetic Variation in Foliation Dates Among Black Walnut Clones

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The breaking of dormancy is one of the most important events in the yearly cycle of woody plants in the temperate zones. The phenology of foliation date has been investigated in many woody plant species including black walnut (BEY, 1971; LINDSEY and NEWMAN, 1956; WOOD, 1934).

Beyond the purley academic interest in foliation date, the practical implications are most significant. If a woody plant breaks dormancy too early, late frost may kill the expanding bud and its attendant reproductive structures, reduce growth, and in the case of timber species destroy desirable form. On the other hand seasonal growth may be reduced by late flushing (NIENSTAEDT, 1958).

Black walnut *(Juglans nigra* L.) is extremely sensitive to frost after growth has begun in the spring (TRYON and TRUE, 1964). Usually, the entire new shoot is killed at 28° F. As BRINKMAN (1957) states, "Throughout its wide range, it reaches greatest size and value on moist, fertile sites, gencrally along streams and at the base of north — or east — facing slopes." Unfortunately, the better sites are also areas that collect cold-air drainage from the uplands, and thus, tend to be "frost pockets."

If, through selection and breeding, strains can be developed that are inherently later flushers, and at the same time rapid growers, the problem of frost damage can be alleviated. On the other hand frost damage may not cause poor form in black walnut. Perhaps certain clones have the ability to produce straight leader growth after severe late spring frosts.

Foliation and flowering dates have been shown to be under genetic influence in both black walnut and Persian walnut *(Juglans regia* L.). According to BEY, TOLIVER and ROTH (1970) southern seed sources of black walnut tended to flush earlier than northern seed sources, but there was great variation within seed sources in flushing. They state that, "selection within sources would lead to considerable gain in late-flushing types." WOOD (1934) found that time of flowering in Persian walnut was inherently late in some grafted cultivars and early in others. Flowering in walnut is closely related to foliation date since the female is borne on the new growth shortly after flushing (WOOD 1934). However, there may be some mechanism for dormant lateral buds to produce late flowers in some clones so that frost would not cause injury to the current year's nut crop.

Materials and Methods

The study is based on 144 living grafts of 27 clones selected for outstanding form and size in an area 80 miles wide by 260 miles north-south from southern Michigan to southern Indiana (BEINEKE and LOWE, 1969). The grafted clones were grown at Shidler Experimental Forest, approximately 8 miles west of Purdue University, West Lafayette, Indiana.

The grafts were made in 1969 on 3 year-old rootstocks according to the methods outlined by LOWE and BEINEKE (1969). Only those selections having at least three successful grafts per celection were included in the study.

In 1970 and 1971 foliation date was recorded at 2-day intervals. A graft was considered flushed if one entire leaf was separated from the bud. The foliation date was measured as the number of days since the first graft in the entire study flushed. Height growth was measured at the close of the 1970 and 1971 growing seasons. Sweep was recorded in 1972 as the maximum deviation of the central stem from the vertical per foot of tree height. Amount of pruning required after severe frost was rated subjectively on a 1, 2, 3 scale. Foliation dates, height, growth and sweep were analyzed by analysis of variance using a completely randomized design .

Results and Discussion

Flushing began on April 25 and 21 and ended May 12 and 21 in 1970 and 1971 respectively. Much above average temperatures from April 16 to April 20, 1971 stimulated earlier flushing in 1971 than in 1970; but in 1971 flushing was slower and more prolonged due to much below average temperatures for two weeks during flushing. In 1970 frost (32° F. or below) occurred on 3 days during the period of flushing but none was severe enough to inflict damage. However, in 1971, ceven frosts occurred. Five frosts damaged the expanding buds of 10 early flushing clones.

Highly significant differences among clones at the 1% level were found in foliation date, total height in 1970, and sweep. Height growth in 1971 showed significant differences among clones at the 5% level. In addition highly significant differences in foliation date were found between years.

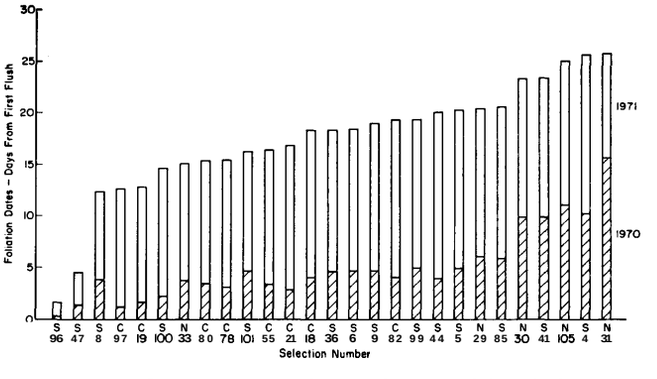

Figure 1. — Comparison of foliation dates in 1970 and 1971. Letters S, C, and N indicate geographic source, respectively, southern, central, or northern.

Figure 1 shows little difference in rank of foliation date among clones from 1970 to 1971 and the correlation coefficient (r) between foliation date in 1970 and 1971 was 0.80. Thus a late flusher in 1970 was usually a late flusher in 1971. Broad-sense heritability in foliation date for both years combined was .85. Broad-sense heritability of total height in 1970, height growth in 1971 and sweep was .55, .16, and .30, respectively.

In both years there was little variation in foliation date within clones. Most grafts from the same selection flushed within one or two days of each other. The longest period of

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flushing within a clone, nine days, occurred in 1971 and was due to frost damage and a cold period during flushing.

A late foliator is not necessarily a slow grower since the correlation coefficient (r) between foliation date and growth in 1971 was —0.02 *(Fig. 2)*. Ten selections are both above average in growth and later than average in foliation date so that both rapid growth and late foliation could be selected in a single clone.

One of the most interesting phenomenon to emerge from the study are the five latest flushers which were grouped together both years. Two of the five are southern sources *(Fig. 1)*. Four of the five late flushers are above average and among the best ten in growth *(Fig. 2)*. Using May 10 as the first frost-free date in the area, in 1970 only selection 31 would have entirely escaped frost if it would have occurred on that date, while in 1971 none of the five late flushers would have sustained frost damage *(Fig. 1)*.

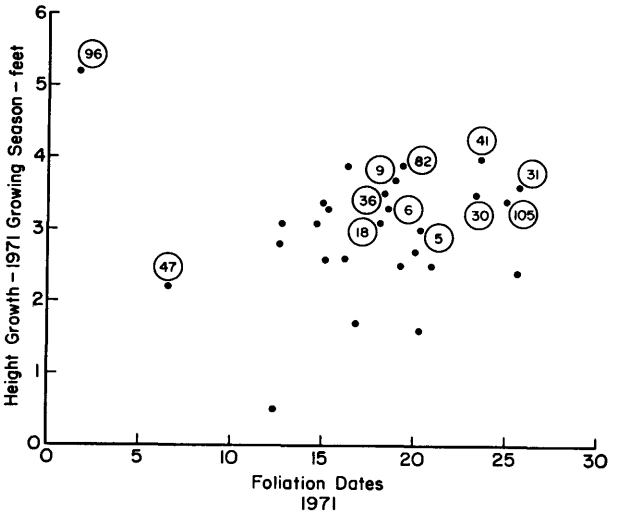

Figure 2. — Lack of correlation of height growth and foliation dates in 1971. Circled numbers identify selection number.

However early foliation and frost damage does not necessarily cause poor form. Sweep, an objective measure of form, was not correlated with foliation date (r = —0.03), and several clones with early to medium foliation dates have excellent form. In addition amount of pruning required after frost was not correlated with foliation date (r = 0.002).

Frost damage to flowers and consequently nut production in seed orchards is apparently of greater importance than poor form caused by frost. Date of male catkin dehiscence in 1972 was correlated with foliation date in 1972 (r = .54). Male catkins in very early stages of growth are easily damaged by late frost and the female flower within the expanding terminal bud is destroyed by temperatures that do not kill all of the expanding leaves. Two of the 27 clones in the study produced female flowers very late in the spring of 1973 from dormant lateral buds that were relatively immune from late frosts. However, male and female flowers on 20 clones that produced flowers were destroyed by late severe frosts.

In *Figure 1*, geographic locations of the selections are noted according to northern, central, or southern divisions. The area from southern Michigan to southern Indiana was divided approximately into thirds. The grafted study area is located in the northern portion of the central zone.

On the average, northern sources tend to flush later than southern sources, but no significant differences were found at the 1% or 5% levels of significance among northern, central and southern sources. This lack of a general trend is shown by southern Indiana selections 4 and 41 which flush as late as the southern Michigan selections 105 and 31 *(Fig. 1)*. North-south distance between these two areas is approximately 210 miles.

In five instances there were two or three selections located in the same stand or in neighboring stands separated by less than one mile. These provide examples of differences in foliation date within stands. The greatest variation was shown among selections 96, 36, and 99 which were separated by less than one mile in southern Indiana. In 1971, the difference in foliation date between 96 and 99 was 17 days, and the difference between 96 and 36 was 16 days. Other selections from the same stands included 18 and 19 (5 days difference in foliation date); 4 and 5 (5 days difference); 29 and 30 (3 days difference); and 31 and 105 (one-half day difference) *(Fig. 1)*.

Summary

Large significant differences and high broad sense heritabilities were found in foliation date among clones of black walnut. Foliation date is not correlated with height growth, therefore, it is possible to select for late foliation date without sacrificing growth. This study utilizing grafted selections of black walnut, shows adequate variation and heritability to further breed for late foliation and hence frost avoidance. However, sweep and amount of pruning required was not correlated with foliation date indicating that frost damage to early foliators does not cause poor form. No significant differences in foliation date were found among northern, central and southern sources.

Key words: genetic variation, foliation dates, *Juglans nigra* L., selection against frost damage.

Zusammenfassung

Nach der Auswahl von 27 Einzelbäumen von *Juglans nigra* L. in einem Gebiet von 80 Meilen Breite und 260 Meilen Länge in nordsüdlicher Richtung vom südlichen Michigan bis zum südlichen Indiana erfolgte deren vegetative Vermehrung durch Pfropfung. Die Pfropfklone wurden im Shidler Experimental Forest, etwa 8 Meilen westlich der Purdue Universität, in West Lafayette, Indiana, ausgepflanzt.

Die Untersuchung der Pfropflinge ergab signifikante Unterschiede im Austreibetermin im Frühjahr, wobei dieser mit dem Höhenwachstum nicht korreliert ist. Es wird daraus geschlossen, daß die Auswahl von Spättreibern und deren vegetative Vermehrung zur Gewinnung von frostharten *Juglans nigra* möglich ist. Gleichzeitig eröffnen sich auf Grund der beobachteten Variation Möglichkeiten für die Züchtung.

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