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Populational Differences in Bud Bursting of *Carpinus caroliniana* Walt.

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Abstract

Twig samples collected from latitudinally diverse populations (between 31 and 43° N) in winter condition, and subsequently exposed to controlled temperature treatments in growth chambers, indicated ecotypic differences in bud bursting response. Exposure to cold treatment prior to placement under long days (16-hour photoperiod) and warm temperatures (day–night cycle of 24–16 C), reduced time required for bud burst in all populations, but a latitudinal cline was apparent with more southern populations having earlier bud burst. Under longer exposure to cold of at least 4 C, populations from intermediate latitudes showed slower response to bud burst than the extremes of the latitudinal range tested, indicating a protective mechanism to prevent bud burst in more variable habitats with unpredictable spring temperatures.

Introduction

Since Turesson's (1922) pioneering study of ecotypes, significant research has shown many species to be composed of discrete populations with physiological and morphological differences enabling each population to cope more effectively with its particular environmental regime. Literature reviews have revealed that, when considering the total number of plant species, relatively few have been subjected to intensified or even superficial investigations of populational differentiation (Hiesey and Milner 1965).

Carpinus caroliniana Walt. (commonly called ironwood, blue beech, American hornbeam, or water beech; Fernald 1950) is a dominant understory species in eastern North America; its range extends from Nova Scotia to Minnesota and south to Texas and Florida. Wide distribution and relative abundance makes ironwood an ideal species for ecotypic and community investigations.

Despite the abundance of *Carpinus caroliniana*, very little information has been published about it. A survey of such references as Excerpta Botanica, Biological Abstracts, and Dissertation Abstracts confirmed that there is virtually no information on the autecology of the genus. This is not unexpected since it is currently of little economic importance. As wood and fiber demands increase, this seemingly noneconomic tree may prove to be an important source of wood fiber. In the past, ironwood has been utilized for wagon axles, spokes, implement handles, and mallet heads, and charcoal of hornbeam was often mixed with gunpowder (deWit 1966). *Carpinus* reportedly accumulates higher than normal amounts of aluminum (Kruckeburg 1969) availing it as a subject for investigating the possibility of its functional niche as an aluminum pump. Populational variation in fruit size has been reported, with larger fruit being evident from more northern habitats (Winstead et al. 1977). The current study is an investigation of the aspects of populational variation in terms of bud bursting.

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Table 1.—Location and description of 9 collection sites of *Carpinus caroliniana* from Michigan to Alabama. All populations were between 83°12′ and 86°49′ W longitude

Population Code	County	State	N. Lat.
M1	Isabella	Michigan	43°29′
M2	Lapeer	Michigan	42°58′
I1	Scott	Indiana	38°42′
K1	Grayson	Kentucky	37°33′
K2	Simpson	Kentucky	36°43′
T1	Davidson	Tennessee	36°07′
A1	Limestone	Alabama	34°48′
A2	Montgomery	Alabama	32°18′
A3	Covington	Alabama	31°10′

Materials and Methods

Collection sites were established for comparisons of widespread populations along a north–south line between 83 and 86°W and a latitudinal distribution between 31 and 43°N (Table 1).

Buds were collected in late December 1975 from 2 trees at each of 9 sites (Table 1), placed in a cold chamber, and maintained at 4 C until removed for testing. Twenty twigs from each population were cut to approximately 20 cm, put in a test tube with tap water, and covered with a plastic bag. The twigs were then placed in an environmental growth chamber (Environator Corporation model 3448) with a day–night temperature of 24–16 C and a 16-hour photoperiod with light intensities of 6,500 to 8,600 lux. All buds were checked daily for evidence of bursting.

Periods of exposure to temperatures below 4 C in the field were calculated for each population from information provided by the National Climatic Center, National Oceanic and Atmospheric Administration, Asheville, N.C.

Results

Winter buds of *Carpinus* collected from field populations and placed in a growth

Table 2.—Populational differences in bud bursting of *Carpinus caroliniana* under controlled environmental conditions of 16-hour days and 24–16 C

Population Code	M1	M2	I2	K1	K2	T1	A1	A2	A3
PROGRAM I									
Days below 4 C prior to test[1]	75	80	72	61	43	51	56	40	47
Days required for 25% bud burst	33	—	34	19	26	23	20	18	18
Days required for 50% bud burst	—	—	51	20	27	27	22	18	19
PROGRAM II									
Days below 4 C prior to test	97	102	93	83	65	72	78	62	69
Days required for 25% bud burst	18	19	26	16	17	17	14	12	13
Days required for 50% bud burst	21	23	28	18	20	19	14	13	13
PROGRAM III									
Days below 4 C prior to test	118	123	114	104	86	93	99	83	90
Days required for 25% bud burst	9	11	19	10	10	9	9	9	8
Days required for 50% bud burst	10	14	—	13	12	13	10	10	9

[1] Days below 4 C prior to test include field conditions before 9 Jan 1976, as well as days held in cold chamber at 4 C subsequent to collection. Program II conditions include an additional 22 days of 4 C than twig cuttings in Program I; Program III conditions include an additional 21 days of 4 C than Program II and 43 days additional cold treatment than Program I.

chamber at regular intervals displayed a possible ecotypic response to the amount of cold experienced prior to springlike conditions. After a minimum of 40 to 80 days at 4 C, a latitudinal response in bud bursting could be seen from Michigan to Alabama (Program I, Table 2). The southernmost populations exhibited 50 percent bud initiation after only 19 days in the growth chamber. As latitude increased northward, so did the time required for maximum bud bursting (up to 51 days).

When subjected to a minimum of 62 to 102 days at 4 C, the time required for 50 percent bud bursting decreased for all latitudes (Program II, Table 1). The Alabama populations continued to display the earliest bud bursting, while the central and northern populations required longer periods to attain 50 percent bud bursting.

The third set of buds (Program III) placed in the growth chamber for 83 to 123 days below 4 C, showed that the northern and southern populations experienced bud bursting at approximately the same time. The material from the central latitudes required a considerably longer period of warm temperatures before initiating spring activity.

Discussion

Winter buds collected from latitudinally diverse field populations demonstrated a high degree of interpopulational variation in response to cold temperature preconditioning. After receiving only 40 to 80 days of temperatures below 4 C, the first program showed apparent latitudinal response to bud bursting with a longer time period required as latitude increased. McMillian and Peacock (1964) documented a similar response in *Prosopis* (mesquite) grown under uniform conditions. They concluded that late bud bursting in northern populations (Oklahoma and Texas) was a selective advantage, preventing frost damage after early warm periods.

The second program of 62 to 102 minimum days at 4 C depicted a similar pattern but with a shorter time between maximum bud bursting in the north and south. Following 83 to 123 days at 4 C, the third program revealed the central latitude populations (Indiana, Kentucky, and Tennessee) retaining the longest dormancy. The northern and southern populations experienced bud bursting at approximately the same time. McNaughton (1967) reported a similar response in altitudinally diverse forest community samples placed under controlled environmental conditions. He reported that woody plants originating from the intermediate elevations required a greater time for maximum bud bursting that did either of the extreme elevations. McNaughton proposed that unstable temperature and frequent late frosts of the intermediate altitudes selected against the early bud bursting genotypes. In regard to *Carpinus*, the central latitudes are noted for their winter thaws and warm periods followed by frost. Without a protective mechanism to prevent spring bud initiation, frost damage would be severe. On the other hand, when spring begins in the northern and southern extremes there is generally little variation, and no need for an extended dormancy.

It may be concluded from this study that ironwood bud bursting is primarily dependent on 2 factors: (1) the amount of cold preconditioning experienced prior to springlike conditions, and (2) the duration of cold necessary to break winter dormancy varies with latitude. Extended cold requirements of the populations at central latitudes in the eastern United States can be viewed as a protective mechanism that impedes spring development during brief warm periods in the winter.

Literature Cited

deWit, H. C. D. 1966. Plants of the World. E. P. Dutton and Co., Inc., New York, N.Y. 208 pp.

Fernald, M. L. 1950. Gray's Manual of Botany. American Book Co., New York, N.Y. 1632 pp.

Hiesey, W. M., and H. W. Milner. 1965.

Physiological and ecological races and species. Ann. Rev. Plant Physiol. 16:203–216.

KRUCKEBURG, A. R. 1969. Soil diversity and the distribution of plants with examples from North America. Madroño 20(3):129–154.

MCMILLIAN, C., AND J. T. PEACOCK. 1964. Bud bursting in diverse populations of mesquite (*Prosopis*: Leguminosae) under uniform conditions. Southwest. Nat. 9(3):181–188.

MCNAUGHTON, S. J. 1967. Genetic control of bud bursting in altitudinally diverse Cascade Forest community samples. Amer. Midl. Nat. 77(2):528–532.

TURRESON, G. 1922. The genotypical response of the plant species to the habitat. Hereditas 3:211–350.

WINSTEAD, J. E., B. J. SMITH, AND G. I. WARDELL. 1977. Fruit weight clines in populations of ash, ironwood, cherry, dogwood and maple. Castanea 42:56–60.