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Determination of the chilling requirement of Arkansas thornless blackberry cultivars

Chrislyn A. Drake and John R. Clark§*

ABSTRACT

Little research has been done to determine the chilling requirement for blackberry cultivars. However, field observations from areas where fewer hours of chilling occur indicate that 'Navaho' requires more hours of chilling than does 'Arapaho'. The objective of our study was to determine a method for measuring the chilling requirement using whole plants of two blackberry cultivars, Arapaho and Navaho. One-year old, bare-root plants were field-dug on 26 October 1999 and placed in a cold chamber at 3°C. Ten single-plant replications of each cultivar were removed at 100-hour intervals up to 1000 hours. The plants were potted and placed in a greenhouse (daily minimum temperature 15°C), and plants were arranged on benches in a completely randomized design. Budbreak was recorded on a weekly basis. Data for budbreak were analyzed as a two-factor factorial (2 cultivars and 10 chilling treatments) by SAS and means were separated by least significant difference ($P = 0.05$). Data indicated that the chilling requirement for Arapaho is between 400 and 500 hours. For Navaho, the data indicated the chilling requirement was between 800 and 900 hours. These data support previous observations and indicate that the method used was successful in determining the chilling requirement for blackberries.

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§ John R. Clark, faculty sponsor, is a professor in the Department of Horticulture.

INTRODUCTION

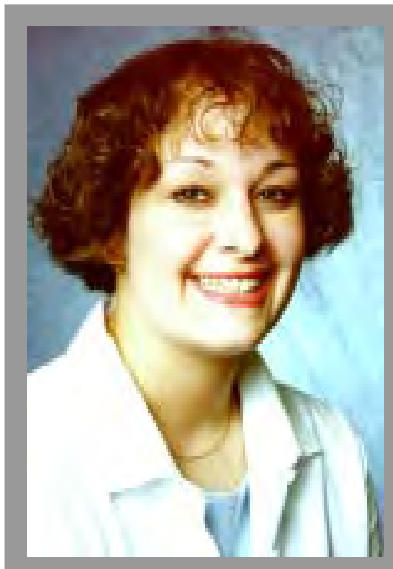
Most temperate-zone perennial woody plants require some degree of rest in order for the buds to break uniformly the following season. This rest period is a type of safety mechanism that keeps buds from breaking under the wrong environmental conditions, such as warm periods in the middle of the dormant season. "Rest period" is defined as the duration that a plant must be exposed to cold temperatures under 7°C in order for normal shoot or flower development to occur in the spring (Ryugo, 1998). The chilling requirement is the amount of cold needed to satisfy the rest period (Ryugo, 1998). If the chilling requirement of a plant is not met, poor budbreak and growth will occur the following season.

However, the chilling requirement is not the same for all woody plant species. For example, apples (*Malus x domestica* Borkh.) need an average of 1200 to 1500 hours of chilling, while almonds [*Prunus dulcis* (Mille) D.A. Webb] need only 200 to 350 hours (Ryugo, 1998). In addition, the chilling requirement is not the same for all cultivars of a particular crop. Extensive research has been done to estimate the chilling requirement for peach [*Prunus persica* (L.) Batsch] cultivars and showed a wide variance: 'Idlewild' requires only 550 hours of chill, while 'Contender' and 'Nectar' require 1050 hours (Parker and Werner, 1993).

Although thorough research has been conducted with peach, no such formal research has been done on blackberry (*Rubus* subgenus *Rubus* Watson), which has become a widely grown horticultural crop in Arkansas and other areas of the United States in recent years. This interest in blackberries is partially exemplified by the development and release of blackberry cul-

tivars from the University of Arkansas. Some of these cultivars are 'Choctaw' (Moore and Clark, 1989a), Navaho (Moore and Clark, 1989b), Arapaho (Moore and Clark, 1993), 'Kiowa' (Moore and Clark, 1996), and 'Shawnee' (Moore *et al.*, 1985). However, growers in southern regions of Arkansas and in subtropical climates have encountered problems with poor budbreak in some of these cultivars, presumably because the chill requirement was not met. Most chilling information on Arkan-

Meet the Student-Author



Chrislyn Drake

I am from Rogers, Ark., and received my degree in horticulture in May. I received the Vaile-Watts Award for outstanding graduate in the Horticulture Department as well as the E. Ted Sims, Jr., Scholarship from the American Society of Horticulture Science—the only one given each year nationally.

I'm staying at the University of Arkansas to get my master's degree; I plan to get a Ph.D. as well but I am not sure where. I chose this research project because Dr. Clark suggested that I get a feel for research before starting my master's program. Nothing had been done to determine the chill

hours needed for the Arkansas blackberry cultivars. It seemed like something that really needed to be done, and it seemed like an interesting project. From this experience, I learned that everything doesn't go as planned! I had a rabbit get into the greenhouse and destroy some of my material, but everything worked out in the long run. I also learned that you really have to be on your toes and make sure to get everything done when it's supposed to be done.

I got interested in horticulture through my family's farm. We moved to Arkansas in 1991, after my parents bought a blueberry farm in Rogers. Since then, we've added blackberries, raspberries, and apples. I worked there in the summers and got to see many aspects of horticulture.

Arkansas blackberries has been derived from observed research generated by researchers and growers in southern areas of the United States (such as coastal Mississippi and Florida) or other countries with warm climates. For example, the thornless cultivar Navaho has been observed to have poor budbreak in southern Mississippi (Creighton Gupton, personal communication, U.S. Department of Agriculture, Poplarville, Miss.) and Florida (Peter Andersen, personal communication, University of Florida, Monticello), presumably because of a lack of chilling. Likewise, the cultivar Choctaw has been found to be the most adapted of the Arkansas cultivars in Mexico and South Africa, which are areas that receive little or no chilling during the winter (J.N. Moore, personal communication). These observations suggest that chilling requirements for blackberry cultivars vary.

Because of these observed differences, the objective of our study was to determine a method for measuring the chilling requirement of blackberry cultivars using whole plants in a controlled environment. Since adequate chilling usually occurs in Arkansas, it was necessary to develop a method whereby the amount of chilling could be controlled and the differences in response measured.

MATERIALS AND METHODS

Arapaho and Navaho were the cultivars used in the study. These two cultivars were chosen because field observations from Hope, Ark., in 1999 indicated that a difference in the chilling requirement might exist in these two cultivars and because plants of Arapaho and Navaho were readily available.

One-year old bare-root plants were field-dug from a local nursery on 26 October 1999 following the first killing frost of the season. Upon arrival in Fayetteville, the plants were heeled-in in containers filled with mulch and placed in a cold chamber at 3°C in darkness. Ten single-plant replications were removed at 100-hour intervals up to 1000 hours. The plants in the 100-hour group were removed from the cold chamber on 30 October 1999, and the plants in the 1000-hour group were removed on 7 December 1999. The plants were cut back to approximately 0.6-m single-cane lengths and potted in 4-L pots using Universal Mix Media (StrongLite Horticultural Products, Pine Bluff, Ark.).

In order to force budbreak, the plants were then transferred to a heated greenhouse with a daily minimum temperature of 15°C and daily maximum range of

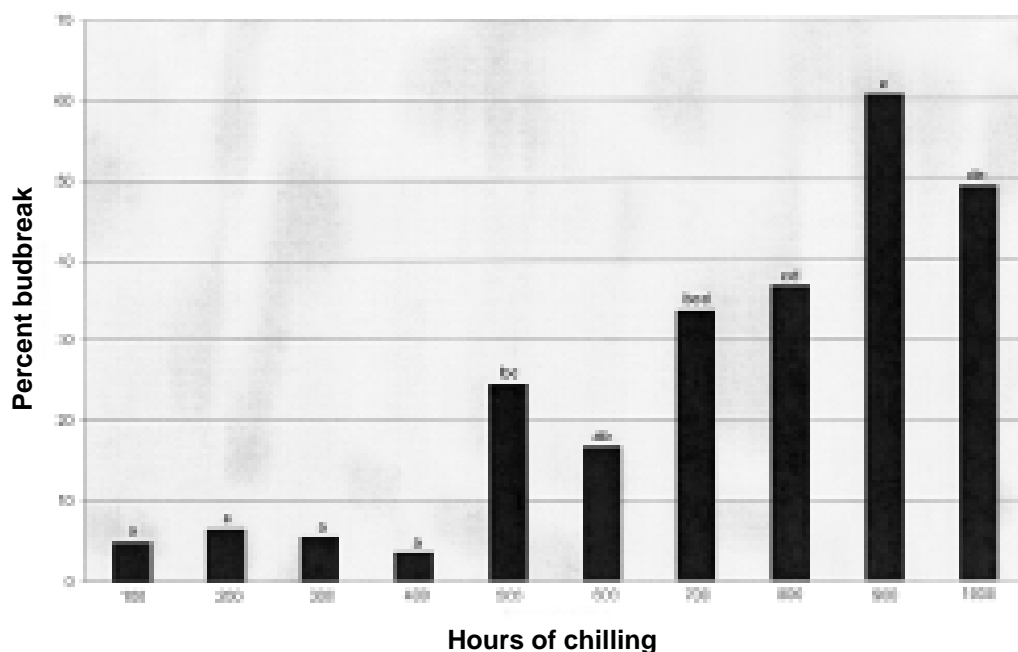


Fig. 1. Budbreak of 'Arapaho' thornless blackberry after 5 weeks of placement in a heated greenhouse following chilling of 100 through 1000 hours at 3°C. Means not followed by the same letter are significantly different as determined by least significant difference ($P = 0.05$).

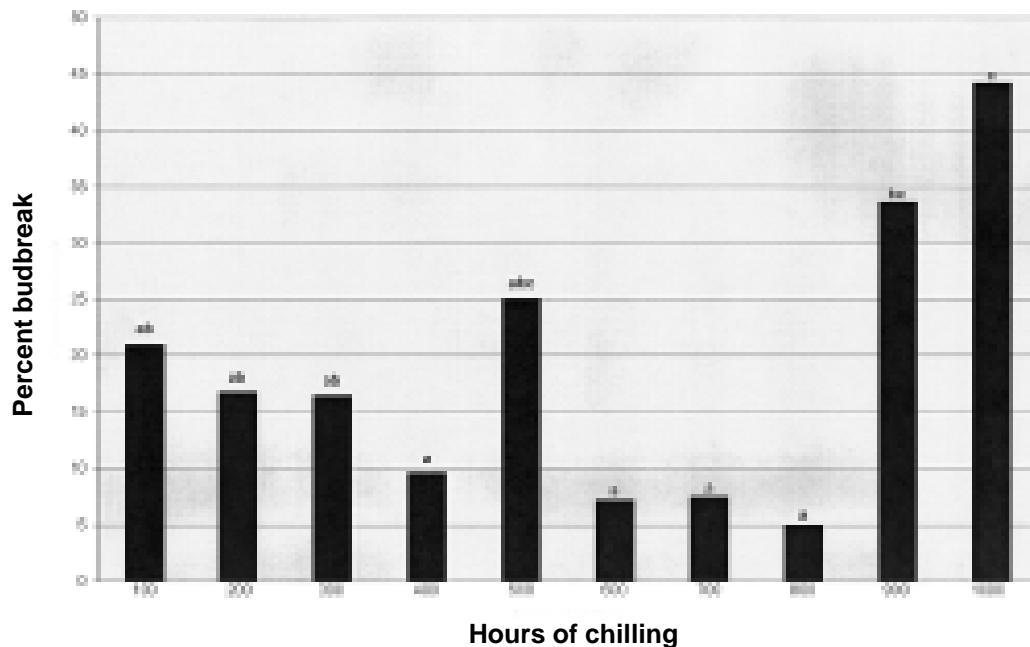


Fig. 2. Budbreak of 'Navaho' thornless blackberry after 5 weeks of placement in a heated greenhouse following chilling of 100 through 1000 hours at 3°C. Means not followed by the same letter are significantly different as determined by least significant difference ($P = 0.05$).

17 to 22°C. The plants were arranged in a completely randomized design. Budbreak data were recorded on a weekly basis. A bud was considered broken when the first leaf became visible as it unfolded from the bud.

Data for budbreak after 5 weeks for each 100-hour chilling treatment were analyzed as a two-factor factorial (2 cultivars and 10 chilling treatments) by SAS (SAS Institute, 1989) and means separated by least significant difference ($P = 0.05$).

RESULTS AND DISCUSSION

Data analysis showed a significant interaction between cultivar and chilling treatment, with the F test showing highly significant probability of 0.01. Based on this finding, main effect means for each cultivar are presented in this discussion.

Budbreak levels were very low for Arapaho for the 100- through 400-hour chilling treatments (Fig.1). At 500 hours, budbreak increased from 4% to 24%, thus indicating a major increase that reflects a probable chilling requirement of between 400 and 500 hours for this cultivar. The slight decrease in budbreak at 600 hours

can be explained by the fact that three plants in this chilling treatment did not break buds until the sixth week, most likely as a result of poor plant health. However, poor health was limited to those particular plants and was not evident in other plants in the study. Budbreak continued to increase with increased chilling, but at no treatment interval was there a similar or significantly higher budbreak than at the 400- to 500-hour interval.

Unlike Arapaho, Navaho exhibited rather high levels of budbreak at the early chill-hour treatments (Fig. 2). This can be explained by presuming that Navaho did not fully enter into dormancy until it had been exposed to chilling temperatures for some time. However, budbreak was low (5% at 800 hours) until the 900-hour chilling treatment. At this level, budbreak increased from 5% to 33%, which was very similar to the large increase in percentage of budbreak at 500 hours for Arapaho. This increase reflects a probable chilling requirement of between 800 and 900 hours for Navaho. Budbreak did increase at the 1000-hour level, but the increase was not as large as the increase in budbreak at the 900-hour level. The 25% budbreak at 500 hours was a substantial varia-

tion in budbreak trend when compared with adjacent chilling periods. This can be explained by the fact that five of the plants in this treatment failed. Of the surviving five plants, two had an extraordinarily high percentage of budbreak, skewing the results to the unusually high level.

The data found in our study correlate with field observations from Hope, Ark., and other areas of the southern United States. During the winter of 1999, Hope only received approximately 600 hours of chilling. Arapaho, which was found to have a chilling requirement of 400 to 500 hours, displayed good budbreak. However, Navaho, which was found to have a chilling requirement of 800 to 900 hours, displayed poor budbreak. Coastal areas of Mississippi and Florida usually receive less than 500 hours of chilling each winter. Therefore, the poor budbreak of Navaho that has been observed in this area is most likely due to lack of chilling.

Because of the correlation between field observations and the results of the study, the whole-plant system appears to be a valid method for evaluating the chilling requirement for blackberry cultivars. Other cultivars can now be evaluated, allowing growers in areas with shorter chilling periods to know which cultivars are best suited for their area.

Subsequent research in this area would be to evaluate the feasibility of using stem cuttings taken from the field as natural chilling accumulates to estimate the chilling requirement rather than using whole plants. A thermograph or other such instrument could be placed in the field to measure hours of chilling, and stem cuttings could be taken at appropriate intervals and placed in a greenhouse in containers of water to force budbreak. A study using stem cuttings would be a much easier undertaking than that of manipulating whole plants in an artificial environment. Also, a stem-cutting study requires much less plant material than a study using whole plants. This is useful when there is limited availability of plant material, such as when a new cultivar is about to be released.

Another possibility for further research could be to explore the chilling efficiencies of specific temperature ranges, as has been done with peaches. For example, in 1974 Richardson, Seeley, and Walker of Utah State

University, Logan, published a chill-unit model for peaches in which 1 chill-unit equals 1 hour of exposure at 6°C. As temperatures rise above or fall below the optimum value, the chilling contribution is less than 1. Negative chill units are accumulated if temperatures rise above 15°C, and there is no contribution if the temperature is below 0°C. As research in this area has been successful with peaches, a study to determine the temperature range chilling efficiencies for blackberries would be a continuation of this project.

ACKNOWLEDGMENTS

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