polyethylene laterals on the soil surface. Although no bud temperature data were collected, canopy ice distribution was similar for overhead wire-supported and stake-supported microsprinklers. Microsprinkler support systems, water distribution patterns, and application rates may need to be modified from those used in this study to protect trees trained to systems other than open center.

Over-tree microsprinkling appears to provide protection similar to that reported for conventional overhead sprinkler systems (Rieger, 1989) and also possesses the same limitation-lack of effectiveness under windy, low-dewpoint conditions. Microsprinkler application rate at the level of fruiting wood (2.5 to 5.0 mm·hr^{-1}) was in close agreement with recommended application rates derived from heat transfer calculations for typical overhead impact systems (Gerber, 1970). The main advantage of over-tree microsprinkling appears to be potential water and energy savings, compared to conventional overhead sprinkler systems. Furthermore, microsprinklers may be more suitable than conventional overhead systems for the application of nutrients, pesticides, and growth regulators, and evaporative cooling for bloom delay or alleviation of heat stress. Multiple uses would help defray the additional cost of the support system. Growers that currently use low-volume irrigation and/or trellis support systems in their- orchards could- easily and economically convert to the over-tree microsprinkler system.

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Chilling Accumulation, Budbreak, and Fruit Set of Young Rabbiteye Blueberry Plants

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Additional index words. *Vaccinium ashei,* dormancy

Abstract. **Potted 'Tifblue', Woodard', and 'Climax' rabbiteye blueberry plants *(Vaccinium ashei* Reade) were exposed to artificial or natural chilling regimes (< 7C) ranging from 100 to 1000 hours during the dormant season to determine the effects on budbreak and fruit set. Insufficient chilling increased the days to 50% vegetative and floral budbreak in all three cultivars. The amount of floral budbreak increased in 'Tifblue' and 'Woodard', but decreased in 'Climax' as chilling increased. Insufficient chilling did not decrease percent fruit set of hand-pollinated flowers in any cultivar, indicating that the fruit-setting potential of these cultivars is unrelated to chilling.**

The blueberry industry in the southeastern United States is based primarily on rabbiteye blueberries, which are native to the southeast and well adapted to the climate and mineral soils (Lyrene and Crocker, 1983). Rabbiteye blueberries are more vigorous and disease tolerant than highbush blueberries, which are also grown in the southeast; however, they generally have a much lower percent fruit set (Davies and Buchanan, 1979; El-Agamy et al., 1981; Lyrene and Crocker, 1983) and may not produce an adequate commercial crop.

Poor fruit set in rabbiteye blueberries is attributable to several factors, including cultivar (Davies and Buchanan, 1979; Lyrene and Goldy, 1983), pollen incompatibility (El-Agamy et al., 1981), presence and activity of bees (Davies and Buchanan, 1979; Payne et al., 1989), and proximity to pollenizers (Lyrene and Crocker, 1983). In addition, field observations (Lyrene and Crocker, 1983) suggest that insufficient chilling decreases fruit set of rabbiteye blueberries. After mild winters, some rabbiteye cultivars bloom normally, but fail to set fruit adequately; also, percent fruit set improves from the southern to the northern end of the rabbiteye production area. Furthermore, there appears to be a positive correlation between yield and amount of chilling for some cultivars (Lyrene and Crocker, 1983). This relationship has led to the idea that insufficient chilling produces flowers with inherently less capacity to set fruit.

Insufficient chilling of blueberries and other deciduous fruit crops results in delayed and erratic budbreak (Amling and Amling, 1980; Gilreath and Buchanan, 1981; Spiers, 1976; Spiers and Draper, 1974) and delayed fruit development (Erez, 1987). However, there are no quantitative data to support the observations on chilling and fruit set of rabbiteye blueberries. The objective of this study was to determine the effects of dormant-season chilling on budbreak and subsequent fruit set of rabbiteye blueberry.

Outdoor experiment. Two-year-old dormant 'Woodard' and 'Tifblue' rabbiteye plants obtained from a commercial nursery were planted in 1 peat :1 pine bark (v/v) in 11.4-liter plastic pots in early January. Twenty-five plants of each cultivar were grown outdoors under natural light and temperature conditions beginning 5 Jan. 1983. Plants had not been exposed to temperatures below 7C before that time. On 12 Jan. and every 2 weeks through 8 Mar., 10 plants (five of each cultivar) were randomly selected and moved into a greenhouse. Maximum/minimum greenhouse temperatures were 33/15C and photosynthetic photon flux (PPF) ranged from 300 to 1200 µmol·s^{-1}·m^{-2}. The number of hours below 7C for each group was recorded with a hygrothermograph. The number of chilling hours received by each group of plants was 134, 253, 320, 370, and 420, respectively.

Every 2 to 3 days during bloom, open flowers from each cultivar were tagged and cross-pollinated by hand using fresh pollen from the other compatible cultivar. Pollen was transferred with the thumbnail to the receptive stigma between 10:00 AM and noon, when greenhouse temperatures ranged from 20 to 27C. An average of 29 'Woodard' flowers/plant (range = 18 to 37) and 36 'Tifblue' flowers/plant (range = 33 to 41) were pollinated. Final fruit set percentage

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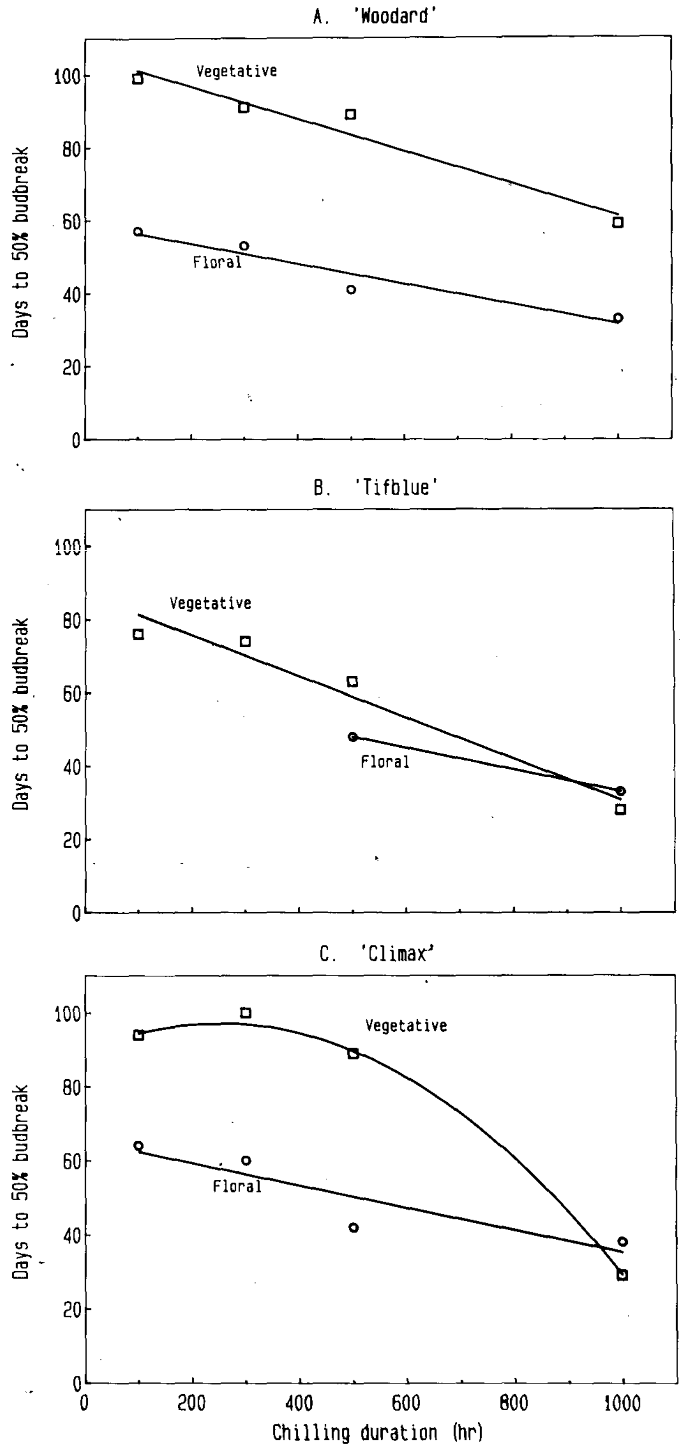

Fig. 1. Days to floral and vegetative budbreak in ‘Woodard’ **(A),** ‘Tifblue’ **(B),** and ‘Climax’ **(C)** rabbiteye blueberries after various cold chamber chilling durations. (Only 10% of ‘Tifblue’ floral buds opened at chilling durations of 300 hr or less.) ‘Woodard’ vegetative: y = - 0.04x + 105.6, r^2 = 0.95; floral: y = –0.03x + 59.0, r^2 = 0.93. ‘Tifblue’ vegetative: y = –0.06x + 87.0, r^2 = 0.95. ‘Climax’ vegetative: y = – 10-%^{2} + 0.06x + 89.7, r^2 = 0.99; floral: y = –0.03x + 65.3, r^2 = 0.81. Data points are means of four replications.

was determined cm 26 Apr., after the fruit drop period for all groups had ceased.

Cold chamber experiment. Three-year-old actively growing ‘ Woodard’, ‘Tifblue’, and ‘Climax’ rabbiteye blueberry plants were planted in June 1987 in 22-liter plastic pots containing peat and grown outdoors. In early November, before receiving any natural chilling, 16 plants of each cultivar were placed in the greenhouse. Average maximum greenhouse temperature was 31 ± 2C and average minimum temperature was 16 ± 3C. Midday PPF ranged from 200 to 635 μmol·s^{-1}·m^{-2}.

Four plants of each cultivar were exposed to 100, 300, 500, or 1000 hr of constant chilling at 7C in a dark chamber. Starting with the 1000-hr treatment, plants were removed from the greenhouse, defoliated, and placed in the chamber at the appropriate intervals. Plants from all four chilling treatments were returned to the greenhouse on 19 Dec. Although the cold chamber chilling regime is artificial, it reduces the possibility that high daytime temperatures during the outdoor experiment might have negated some of the chilling received or that a greater amount of chilling was received than recorded due to accumulation at temperatures above 7C (Gilreath and Buchanan, 1981; Shine and Buchanan, 1982).

An average of 96 ‘Climax’ (range = 76 to 123), 223 ‘Woodard’ (range = 172 to 301), and 133 ‘Tifblue’ flowers per plant (range = 5 to 299) were pollinated as described in the outdoor experiment. The rate and amount of vegetative and floral budbreak were determined from 19 Dec.-3O May. Final fruit set percentage was determined 25 July. All data were analyzed-by regression. Fruit set percentages for both experiments were adjusted using arcsin transformation before analysis.

Outdoor experiment. Increasing the amount of chilling decreased the time to floral budbreak in both cultivars. Plants receiving 420 hr of chilling began flowering 12 to 17 days after being placed in the greenhouse, whereas plants receiving 134 and 253 hr began flowering after 36 to 48 days. This delay is less than that observed previously when these cultivars were exposed to constant chilling of similar durations (Spiers and Draper, 1974). Our plants may have accumulated more chilling than estimated by the total number of hours below 7C, since this method does not account for chilling at temperatures above 7C or fluctuating temperatures, both of which are reported to influence chilling accumulation in blueberries (Giheath and Buchanan, 1981; Spiers, 1976). However, calculation of chilling units by the model of Shine and Buchanan (1982) gives similar results (within 7%). There was no effect of chilling on the total number of floral buds which broke, averaging 30 to 40 per plant for both cultivars.

Suboptimum chilling (as evidenced by the delay in flowering) did not decrease the fruit set percentage in either cultivar. Percent fruit set was independent of the number of chilling hours, ranging from 43% at 420 hr to 83% at 320 hr for ‘Woodard’ and from 52% at 420 hr to 90% at 370 hr for ‘Tifblue’. The range in fruit set percentages within each cultivar may be related to environmental conditions during and after pollination. The percent fruit set in ‘Woodard’ approximated that in the field (40% to 66%) (Davies and Buchanan, 1979; Lyrene and Goldy, 1983). The fruit set for ‘Tifblue’, however, was much higher than that found in the field in Florida (10% to 36%) (Davies and Buchanan, 1979; Lyrene and Goldy, 1983), suggesting that low fruit set percentages for ‘Tifblue’ in the field may be related to pollination or environmental factors, rather than to inherent differences in the fruit-setting capacity of various cultivars.

Cold chamber experiment. Days to 50% vegetative and floral budbreak decreased with increased chilling for all cultivars, although the pattern of vegetative budbreak relative to

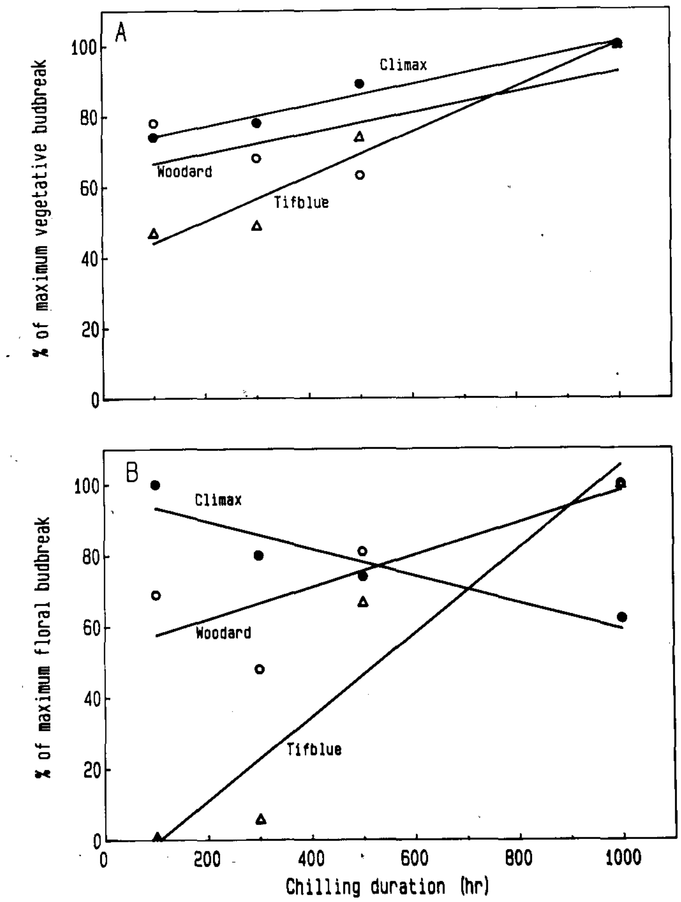

Fig. 2. Percent vegetative **(A)** and floral **(B)** budbreak in 'Woodard' (❍), 'Tifblue' (▲), and 'Climax' (●) rabbiteye blueberries after various cold chamber chilling durations. Vegetative budbreak: 'Woodard' y = 0.03x + 63.5, r^2 = 0.46; 'Tifblue' y = 0.06x + 37.6, r^2 = 0.95; 'Climax' y = 0.03x + 71.1, r^2 = 0.97. Floral budbreak: 'Woodard' y = 0.06x + 53.0, r^2 = 0.64; 'Tifblue' y = 0.12x – 12.5, r^2 = 0.89; 'Climax' y = –0.04x + 97.2, r^2 = 0.86. Data points are means of four replications.

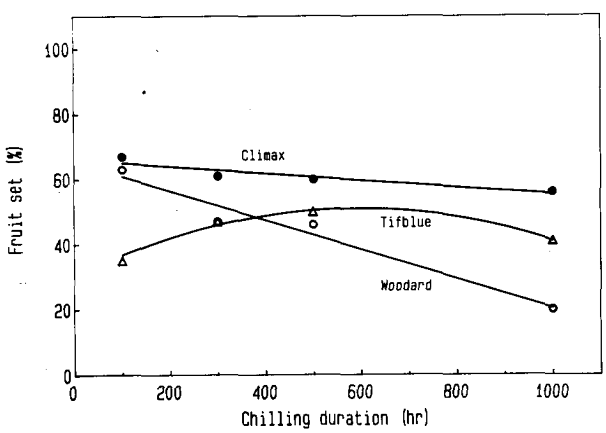

Fig. 3. Percent fruit set in 'Woodard' (❍), 'Tifblue' (▲), and 'Climax' (●) rabbiteye blueberries after various cold chamber chilling durations. 'Woodard' y = – 0.05x + 65.6, r^2 = 0.96; 'Tifblue' v = –6.0 X 10-%^{2}+ 0.07x + 30.4, r^2 = 0.98; 'Climax' y = –0.01x + 66.4, r^2 = 0.83. Data points are means of four replications.

floral budbreak differed among cultivars (Fig. 1). Time to 50% budbreak decreased similarly for both vegetative and floral buds of 'Woodard' as chilling increased; however, floral buds broke before vegetative buds for all chilling treatments (Fig. 1A). This was also noted by Spiers and Draper (1974) and suggests that 'Woodard' flower buds may have a lower chilling requirement than leaf buds. In contrast, only 10% of the floral buds of 'Tifblue' opened with chilling durations of 300 hr or less. This trend was not observed in the outdoor experiment and may indicate that plants in the outdoor experiment received slightly greater amounts of chilling than recorded. 'Tifblue' vegetative buds, however, opened after 100 hr of chilling, although the rate of opening was very slow. As chilling time increased, the time to 50% vegetative budbreak decreased linearly. After 1000 hr of chilling, the times to vegetative and floral budbreak in 'Tifblue' were equal (Fig. 1B).

Budbreak in 'Climax' differed from the other two cultivars (Fig. 1C). The time to floral budbreak in 'Climax' decreased linearly as chilling increased. However, vegetative budbreak was not affected by increases in chilling between 100 and 500 hr, resulting in an increasing delay between vegetative and floral budbreak. Between 500 and 1000 hr of chilling, the time to vegetative budbreak decreased dramatically, resulting in vegetative budbreak occurring slightly before floral budbreak. The chilling requirement of 'Climax' is ≈500 hr (Austin et al., 1982); thus, the rapid decrease in the time to vegetative budbreak after 500 hr may indicate that the growing degree hour requirement for vegetative budbreak in 'Climax' is reduced by excess chilling (Couvillon and Erez, 1985).

The percentage of vegetative budbreak (calculated as the amount of budbreak at a given chilling time relative to the maximum amount of budbreak which occurred) increased with increasing chilling duration in all cultivars (Fig. 2A). A similar increase was observed in the percentage of floral budbreak in 'Woodard' and 'Tifblue' (Fig. 2B). 'Climax', however, exhibited a 40% decrease in floral budbreak as chilling increased from 100 to 1000 hr. The reason for this is unclear, since flower buds appeared normal when plants were removed from the cold chamber. Austin et al. (1982) reported a 75% decrease in floral budbreak without any apparent flower bud damage when 'Climax' was exposed to more than 850 hr chilling.

As found in the outdoor experiment, suboptimum chilling did not decrease fruit set in any of the cultivars (Fig. 3). In fact, there was a decrease in fruit set with increased chilling in 'Woodard' and, to a much lesser extent, in 'Climax'. 'Woodard' had a significantly greater number of flower buds that opened than did the other two cultivars, particularly at 500 and 1000 hr chilling. The decrease in fruit set as chilling progressed may reflect increased competition among these flowers, as has been observed in apple (Knight, 1980). The average percent fruit set in 'Woodard' and 'Climax' was 44% and 61%, respectively, closely approximating those for mature bushes in the field (Davies and Buchanan, 1979; Lyrene and Crocker, 1983). 'Tifblue' averaged 44% fruit set, again suggesting that fruit set in 'Tifblue' is not inherently low, but is affected by environmental factors in the field.

Although leaf : fruit ratios were not determined in this study, there is no evidence to suggest that different canopy areas affected fruit set. Previous work indicates that leaf area is not correlated with initial fruit set of blueberry. Percent fruit set of field-grown rabbiteye cultivars was similar for two seasons even though flowering occurred ≈3 weeks before leafing the first year and concurrently with leafing the 2nd year (Davies, 1986). Some rabbiteye cultivars yield poorly in Florida, especially after mild winters. Our data suggest this is probably due to a reduction in the number of floral buds that break and/or a decrease in bloom concentration, which may lead to pollination inefficiency, rather than to a direct effect of insufficient chilling on the inherent fruit-setting capacity of the flower. Although the plants were young and in pots, budbreak response to chilling and percent fruit set were similar to mature field-grown plants. Thus, there is no evidence to suggest that insufficient chilling produces inherently weak flowers.

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Feasibility of Broccoli as a New Enterprise—A Systems Approach

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Abstract. **An interdisciplinary systems approach was used to explore the potential of fall, fresh-market broccoli as a new enterprise for eastern Virginia. Thirteen cultivars were evaluated in three plantings. Crop value was estimated at each harvest based on weekly market prices. The market window was open from mid-October until late November, with production of 160 cartons/ha, each at 11 kg. However, production of 120 cartons/ha narrowed the window to 2 weeks. Yield of some cultivars exceeded 160 cartons/ha in the first planting; yield of others was below the target production in the second planting. Low yield and low prices during most of the harvest period for the second planting suggests that the optimum harvest season ends in mid- to late November. Problems with poor plant establishment must be addressed before growers can fully capitalize on potential of broccoli as a new enterprise.**

Vegetables are frequently considered a viable option for diversification by agricultural producers. The decision to evaluate a new horticultural enterprise requires the careful consideration of many factors. Grower interest is essential, as is grower willingness to address the specific needs of a new crop. Concurrent evaluations of trends in per capita consumption, potential demand for the commodity, condition of the market windows, seasonal patterns of production, and possible competition need to be completed (Bauer et al., 1987; Runyan et al., 1986; Sterrett et al., 1989). There are several additional concerns that also must be addressed. Vegetable production is labor intensive and often requires specialized equipment, skilled production management techniques, and unique postharvest handling to produce and maintain the quality product needed to be competitive in the marketplace (CAST, 1984; Kline et al., 1986). The interdisciplinary approach includes the evaluation of the production feasibility and the economic and marketing potential to establish a realistic assessment of new enterprise combinations (Sterrett et al., 1989).

This study focuses on the production feasibility of fall broccoli as a new enterprise for eastern Virginia. In addition to growers' interest, other factors that were involved in the selection of broccoli for evaluation as a new enterprise included an increase of 330% in per capita consumption of broccoli since 1975 (Harem, 1988), the possible extension of the existing harvest window in Virginia to expand existing marketing opportunities, the possibility that fall broccoli production would fit into the production schedules of currently grown vegetable commodities (potatoes, snap beans, etc.), the proximity of five major terminal markets within a 970-km radius, and the development of a regional farmers market by the state of Virginia that will require a more-diverse product mix.

To estimate potential yields and product quality, as well as determine the potential harvest season, replicated yield trials with 13 cultivars were planted 10 Aug. (week 31), 19 Aug. (week 33), and 10 Sept. (week 36) 1987 on a Bojac sandy loam soil (coarse-loamy, mixed thermic Typic Hapludult) at the Eastern Shore Agricultural Experiment Station, Painter, Va. Three-row plots were 7.6 m long, with 0.6 m between rows and 0.1 m between seeds within the row (26,700 seed/ha). Fertilizer (112N-49P-93K, $kg\cdot ha^{-1}$), B (1.1 $kg\cdot ha^{-1}$), and α,α,α–trifluoro-2,6-dinitro-N,N-dipropyl-p-tolu-

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