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Rejuvenating Rabbiteye Blueberry 'Tifblue' and 'Woodard'

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Abstract. **Hedging reduced yield and increased fruit size of rabbiteye blueberry (*Vaccinium ashei*, Reade) for one or 2 years following hedging, but yields and fruit size were similar to unhedged plants after 4 years. The best hedging treatment time was February, with evaluation taking place over a 5-year period following hedging.**

Under normal growing conditions, rabbiteye blueberry plants will grow to a maximum height of 3 to 4.2 m in a 10-year period. Rabbiteye plants generally are sufficiently vigorous to develop and support heavy crops of fruit (7, 9). However, old rabbiteye blueberry plants are difficult to manage due to large plant size. Older stems seldom produce vigorous shoots, and thus fruit size becomes smaller each year (8). Pruning rabbiteye blueberry plants has been limited to removing low, weak branches, thinning the centers, and occasional removal or "heading back" of older stems (1, 4, 5, 7).

Pruning recommendations for the highbush blueberry are as follows (3, 8): 1) removal of all diseased or injured wood; 2) removal or heading back of the oldest and least vigorous stems; 3) removal of low branches and weak wood; and 4) removal of bushy or twiggy growth, smaller shoots, and heading back fruiting wood if needed.

Mowry and Camp (6) observed that severe hedging of old, large rabbiteye blueberry plants gave an increased yield the 2nd or 3rd year after hedging. Spiers (9) reported that August hedging of 'Tifblue' plants exceeding 1.8 m in height to 1.8 m or selective removal of one-third of the older stems did not reduce fruit yields over unhedged plants the following year in Mississippi. However, hedging to 1.2 m drastically reduced the yield the following year.

This study was undertaken to evaluate the effects of hedging on yield and fruit size of large rabbiteye plants.

Materials and Methods

Expt. 1. Vigorous, 10-year-old 'Tifblue' plants were hedged to 0.6, 0.9, and 1.2 m in Aug. or Dec., 1969. All weak, unproductive wood was pruned from all plants. There were 3 replicates of 10 plants per treatment. Fruit was harvested and sized in 1970, 1971, 1973, and 1974. Size was determined by counting the fruit required to fill a 0.24-liter (half-pint) cup.

Expt. 2. Low-vigor (3.9 MT/ha), 21-year-old 'Tifblue' plants about 2.1 m in height was hedged to 0.6 m on 9 July, 23 July, and 6 Aug. 1975. There were 3 replicates of 5-plant plots of each treatment. Unhedged plants were pruned in a normal manner. Undesirable shoots were removed from all hedged plants on 30 Jan. 1976. Blueberry fruits were harvested and sized in 1976 and 1977. Hedged plants were pruned and prunings were weighed in Feb. 1977 and again on 23 Feb. 1978, along with the unhedged plants.

Expt. 3. Low-vigor, 18-year-old 'Tifblue' and 'Woodard' plants were hedged to 0.3, 0.6, and 1.2 m on 23 July 1976. An unhedged control was included. The plots consisted of 5 plants of each cultivar. There were 3 replications of 'Tifblue' and 2 of 'Woodward'. All plants were pruned during the dormant season for 2 years after hedging. Fruit yields were collected in 1977 through 1980.

Expt. 4. Moderately productive (7.8 MT fruit/ha), 15-year-old 'Tifblue' plants were hedged to 0.6 m on 10 Feb., 7 July, 21 July, and 4 Aug. 1977. Plants were pruned 2 years after hedging, as in expt. 2. Fruit was harvested and sized from 1977 through 1982.

Data were analyzed by ANOVA. Hedged treatment effects were delineated by orthogonal polynomials.

Results

Expt. 1. There was significant interaction among hedging date, hedging treatment, and harvest year. Fruit yield was reduced the first year after hedging (Table 1). Even though the reduction was linear with hedging height, plants hedged to 1.2 m in August had larger yield than shorter-hedged plants, but plants hedged to 1.2 m in December had larger yield than only 0.6-m-hedged plants. By 1971 and continuing through 1974, hedging treatments produced as much as the unhedged plants. Unhedged plants produced more fruit than hedged plants over a 5-year period; the shorter the December hedging, the less fruit was produced.

Hedging increased fruit size in 1970 with fruit size and yield being inversely related. The interactions between hedging treatment and harvest year and between hedging date and harvest year were significant (Table 2). Fruit size decreased each succeeding year, but there were no differences in fruit size between hedged and unhedged plants. Fruit size increased linearly with reduced hedging height both in 1970 and 1973 and over a 5-year period. The average fruit size for 5 years was larger on hedged plants than unhedged plants.

Expt. 2. Hedged plants had less total yield than unhedged plants in both 1976 and 1977 (Table 3). Drought in 1977 reduced yield of unhedged plants below that of 1976, but yields of hedged plants were not reduced by drought. There were 374 mm of rainfall during the ripening season in 1976 (14 May to 30 June), whereas drought occurred during the major part of the 1977 bearing season. Rains occurred for 12 days during the 14 May to 30 June period and rainfall accumulation for 7 of those days was less than 23 mm. There was a significant interaction between year and hedging dates. Yield in both years decreased linearly with later hedging dates.

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Table 1. The effects of height of hedging and time of hedging on the 1970, 1971, 1973, and 1974 yields of 'Tifblue' plants (expt. 1).

1969 hedge treatment	Yield (kg/plant)				
	1970	1971	1973	1974	Total
			August hedging		
Unhedged	4.4	2.0	2.2	1.5	10.1
1.2 m	2.0	2.0	2.1	1.5	7.6
0.9 m	1.0	2.1	2.4	1.5	7.0
0.6 m	0.5	1.7	3.0	1.8	7.0
Significance					
Linear	**	NS	NS	NS	NS
Quadratic	NS	NS	NS	NS	NS
Unhedged vs. hedged	**	NS	NS	NS	†
			December hedging		
Unhedged	3.5	2.1	2.9	1.4	9.9
1.2 m	1.9	1.8	2.0	1.4	7.1
0.9 m	1.0	1.8	2.9	1.4	7.1
0.6 m	0.2	1.4	2.5	1.3	5.4
Significance					
Linear	**	NS	NS	NS	*
Quadratic	NS	NS	NS	NS	NS
Unhedged vs. hedged	**	NS	NS	NS	*

NS,†,*,**Nonsignificant (NS) or significant at 10% (†), 5% (*), or 1% (**) level.

Shorter hedging treatments tended to increase fruit size in 1976, but fruit size in 1977 was smaller from late-summer-hedged plants. Drought in 1977 reduced size below that of 1976. Fruit weight was 1.26 g per berry in 1976 and 0.77 g in 1977.

There were no differences among summer hedging dates in the amount of wood pruned in 1977. An average of 2 kg of wood per plant was removed at each pruning date. Pruning in 1978 averaged 0.3 kg per hedged plant and 1.0 kg from the unhedged plants.

The experiment was discontinued in 1978 since 40% of the plants were weak or died (2).

Expt. 3. Unhedged 'Tifblue' plants had higher yields in 1977 than plants hedged 0.6 and 0.3 m (Table 4). Yields decreased with decreased plant size, but yield was larger in 1978 for the 0.3-m-hedged. There were no yield differences among treatments in 1978 and 1979, but fruit size from hedged plants tended to be larger than other years. Fruit size increased linearly with decreased plant size in 1977 and over the 4-year harvest period.

Table 2. Fruit size of 'Tifblue' as affected by hedging height and harvest year (expt. 1).

1969 hedging treatment	Fruit size (no. fruit/275cc)				
	1970	1971	1973	1974	Avg
Unhedged	105	99	114	104	106
1.2 m	100	100	112	104	104
0.9 m	86	98	106	106	99
0.6 m	76	96	104	109	96
Significance					
Linear	*	NS	*	NS	**
Quadratic	NS	NS	NS	NS	NS
Unhedged vs. hedged	*	NS	†	NS	*
Aug. hedge	91	98	105	106	100
Dec. hedge	93	98	113	105	102
	NS	NS	*	NS	NS

NS,†,*,**Nonsignificant (NS) or significant at 10% (†), 5% (*), or 1% (**) level.

Table 3. Effect of time of hedging on yields and fruit size of 'Tifblue' (expt. 2).

1975 hedging date	yield (kg/plant)			Fruit size (g/berry)		
	1976	1977	Total	1976	1977	Avg
Unhedged	2.6	1.6	4.2	1.22	0.71	0.97
9 July	0.7	0.7	1.4	1.22	0.85	1.04
23 July	0.6	0.5	1.1	1.25	0.80	1.03
6 Aug.	0.3	0.4	0.7	1.33	0.70	1.02
Significance						
Linear	**	**	**	†	NS	NS
Quadratic	NS	NS	NS	NS	*	†
Hedged vs. unhedged	**	**	**	NS	NS	NS

NS,†,*,**Nonsignificant (NS) or significant at 10% (†), 5% (*), or 1% (**) level.

The reduced yields harvested in 1979 for unhedged plants and plants hedged 1.2 m were probably due to low temperatures (7 Mar., 1.1°C; 9 Mar., 1.7°C; 12 Mar., 0.0°C; and 26 Mar., 0.6°C) during blossoming season. Plants hedged 0.6 m in 1980 had higher yields than plants hedged 0.2, 1.2 m, and unhedged plants. Plants hedged 0.6 and 0.3 m tended to have larger fruit than plants hedged 1.2 m and unhedged plants.

The total yield of hedged 'Woodard' plants for 4 years, regardless of height, was less than unhedged (Table 4). The first year after hedging, only 'Woodard' plants hedged 0.3 m had less yield than unhedged plants. However, 2 years after hedging, yields of hedged plants were not significantly different than unhedged plants. Yield increase over the years was linear. Hedging increased fruit size significantly in the first year after hedging only. The more severe the hedging, the larger the fruit size. Fruit size decreased linearly with years.

Expt. 4. Hedging in the winter produced a significantly greater total yield over a 5-year period than summer hedging or the control (Table 5). Also, the average fruit size was larger for the 10 Feb. and 7 July hedge than the control. Considering the total yield for 6 years where there was no fruit from the winter hedge treatment, there were no significant differences among hedging treatments.

There was a significant interaction between year of harvest and hedging dates. There were no differences among summer hedging treatments at any time. Winter hedging had a higher yield than the other hedging treatments in 1979, 1980, and 1982. The lower yields in 1981 were attributed to dry weather conditions during bloom. Average fruit size was smaller in 1981 than other years.

Discussion

Summer hedging in the South should be a better treatment than winter hedging because vigorous rabbiteye plants will produce new shoots that will set flower buds during late summer and early fall. These data confirm that of Spiers (9) who reported that reduced fruit yield and larger fruit size will occur with hedged plants. These experiments show that the total yield from hedged plants measured over a 4- to 5-year period is equal to that of unhedged plants. Winter hedging appeared to be the best hedging treatment for rejuvenating nonvigorous rabbiteye blueberry plants.

Hedged plants require additional pruning to thin out watersprouts. Also, hedged plants need to be hand-harvested for 2 years after hedging in order not to break developing watersprouts

Table 4. Effect of hedging height in 1976 on the yields and fruit size of 'Tifblue' and 'Woodard' (expt. 3).

1976 hedge treatment	Yield (kg/plant)					Fruit size (g/berry)				
	1977	1978	1979	1980	Total	1977	1978	1979	1980	Avg.
					Tifblue					
Unhedged	2.3	2.4	1.8	2.8	9.3	0.86	0.91	1.04	0.92	0.93
1.2 m	0.9	3.1	3.3	5.1	12.4	0.94	0.98	1.15	0.91	1.00
0.6 m	0.3	1.3	2.7	7.8	12.1	0.89	1.08	1.25	0.96	1.05
0.3 m	0.4	1.9	3.1	5.7	11.1	1.01	1.01	1.16	0.95	1.03
Significance										
Linear	*	NS	NS	NS	NS	†	NS	NS	NS	*
Quadratic	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Cubic	NS	*	NS	NS	NS	NS	NS	NS	NS	NS
Hedged vs. unhedged	*	NS	NS	NS	NS	NS	NS	NS	NS	*
					Woodard					
Unhedged	2.3	4.2	4.4	5.2	16.1	0.89	0.93	1.00	0.88	0.93
1.2 m	1.8	2.2	3.9	4.0	11.9	1.02	0.93	0.88	0.83	0.92
0.6 m	1.8	2.7	3.9	4.3	12.7	1.16	1.14	1.10	1.00	1.10
0.3 m	1.2	2.5	3.2	4.9	11.8	1.22	1.22	1.19	1.12	1.19
Significance										
Linear	**	**	NS	NS	*	**	*	NS	NS	**
Quadratic	NS	**	NS	NS	NS	NS	NS	NS	NS	NS
Cubic	NS	*	NS	NS	NS	NS	NS	NS	NS	NS
Hedged vs. unhedged	**	**	NS	NS	*	*	NS	NS	NS	*

NS,†,*,**Nonsignificant (NS) or significant at 10% (†), 5% (*), or 1% (**) level.

Table 5. Effect of time hedging and year of harvest on yield and average fruit size of 'Tifblue' (expt. 4).

1977 hedging date	Harvest year						Total	
	1977	1978	1979	1980	1981	1982	1977–1982	1978–1982
				Yield (kg/plant)				
Unhedged	5.0	3.4	9.4	6.4	8.3	15.1	25.7	20.7
10 Feb.	---	1.8	15.0	9.7	22.5	30.2	34.1	34.1
7 July	3.9	0.9	3.1	5.7	15.0	20.4	23.4	19.5
21 July	6.0	0.8	2.7	5.7	13.4	18.4	24.1	18.1
4 Aug.	6.1	0.8	2.0	5.1	12.6	19.0	23.3	17.1
Significance								
Linear	NS	**	**	†	NS	NS	NS	NS
Quadratic	NS	**	NS	NS	†	NS	NS	NS
Cubic	NS	NS	*	†	*	*	NS	*
Unhedged vs. hedged	NS	**	†	NS	NS	NS	NS	NS
				Fruit size (g/berry)				
Unhedged	---	1.02	1.10	0.96	0.96	1.02	---	1.01
10 Feb.	---	1.22	1.19	1.14	1.03	1.11	---	1.14
7 July	---	1.19	1.33	1.09	0.97	1.15	---	1.15
21 July	---	1.19	1.33	1.03	0.92	1.10	---	1.11
4 Aug.	---	1.19	1.28	1.04	0.93	1.09	---	1.11
Significance								
Linear		*	**	NS	NS	NS		NS
Quadratic		*	*	NS	NS	*		*
Cubic		†	NS	NS	NS	NS		NS
Unhedged vs. hedged		**	**	†	NS	*		*

NS,†,*,**Nonsignificant (NS) or significant at 10% (†), 5% (*), or 1% (**) level.

off the plants. After that, hedged plants can be harvested with a hand-held vibrator or an over-row harvester.

Fruit size of unhedged, large rabbiteye blueberry plants could be very small and require more time, and thus higher cost, to harvest. In addition, more fruit is lost in either hand- or machine-harvest. With reduced yields from hedging, fruit size was increased as reported (3). It has been shown that heavy pruning of highbush blueberry plants resulted in a greater percentage of fruit harvested in early season (3).

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Factors Affecting *in Vitro* Fatty Acid Content and Composition in Asexual Embryos of *Theobroma cacao*

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Abstract. **Asexual embryos of cacao (*Theobroma cacao* L.) were grown for 45 days in a modified Murashige and Skoog (MS) liquid medium with sucrose concentration increased stepwise from 3% to 27% and supplemented with various concentrations of MS salts, inorganic and organic nitrogen (casein hydrolysate), phosphorus, potassium, coconut water, 6-benzylamino purine (BA), naphthaleneacetic acid (NAA), gibberellic acid (GA), and abscisic acid (ABA). Embryo growth decreased but fatty acid accumulation per gram dry weight was unaffected when total salt concentrations were less than full-strength MS levels. Growth and fatty acid accumulation was inhibited as total salt concentrations were increased from 1 × to 8 × full-strength MS levels. Eliminating inorganic nitrogen, organic nitrogen, potassium, and phosphorus from the medium tended to reduce embryo growth and fatty acid accumulation. None of the growth-regulating substances used increased fatty acid accumulation, but high concentrations of BA (10 and 100 ppm) or NAA (100 ppm) were inhibitory; there was little response to GA or ABA. An increase in total fatty acids in all experiments was associated with increased mole percentage of oleic and stearic acids and decreased linoleic and linolenic acids.**

Although the influence of nutrients and growth regulators on fruit development has been studied extensively (3), little is known concerning their influence on storage lipids of developing seeds. The problem is difficult to study *in vivo* because of interactions among plant, fruit, and seed development.

We have established a system for studying the developmental biochemistry of lipids for an oil seed species, *Theobroma cacao* (4, 7, 8, 9, 10). Asexual embryos are first proliferated in solid medium and then induced to develop toward maturity under high sucrose concentrations in a liquid medium. The development of lipids in this system mimics zygotic embryo development *in vivo* (4). The accumulation of fatty acids under this protocol was found to be optimum at 26°C (12). In this study, we investigated the influence of nutrients and growth-regulating substances on asexual embryo growth and fatty acid content of cacao *in vitro*. The nutrient modifications investigated included total MS salts, inorganic and organic nitrogen, potassium, and phosphorus. Growth regulators included coconut water, BA, NAA, GA, and ABA.

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Materials and Methods

Asexual embryos of cacao initiated from immature zygotic embryos (7, 8) were proliferated on an agar-solidified basal medium containing 1.5% (w/v) sucrose. Embryos from a single clone identified as Budding Center 46 were used for all experiments, except a mixture of clones was used in the coconut water study. The control medium used throughout, in mg/liter, consisted of Murashige and Skoog salts, 4330 (6); casein hydrolysate, 1000; myo-inositol, 100; glycine, 2; pyridoxine, 0.5; nicotinic acid, 0.5; and thiamine–HCl, 0.1.