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Reviewed Research Paper

Relationship Between Autumn Growth Cessation and Chilling Requirement in Peach[1]

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Abstract

The relationship between growth cessation under shortening daylengths and chilling requirement was investigated in a low-chill, young peach seedling population and in 6 low-chill peach cultivars. A positive correlation (r=0.32**) was found between growth cessation and chilling requirement in the seedling population, whereas, a negative correlation (r=-0.58**) was found for the 6 cultivars. The 6 cultivars behaved in the manner that was expected; however, growth cessation in the seedlings was confounded by juvenility and vigor. Regression of individual progeny on their midparent values revealed that chilling requirement is highly heritable (h^2=0.93).

Before deciduous woody plants enter dormancy they go through a series of changes that enable them to survive winter freezes. The first stage of acclimation is induced by a response to shortening daylengths which causes growth to cease (3,11). Many woody species have been shown to cease growth under short photoperiods (1,8,10,11,12,18,19,). Plants from higher latitudes generally exhibit this response under longer photoperiods than plants of the same species from lower latitudes.

Breeding improved cultivars of deciduous fruit tree species adapted to areas with low chilling units often requires use of high-chill germplasm as sources of desirable alleles. Progeny derived from crosses of adapted by unadapted genotypes show considerable variation for CR. Preselection for chilling requirement (CR) based on individual seedling growth cessation (GC) in the autumn, as suggested by Lammerts (9) would permit removal of seedlings that have an undesirable CR. These could then be sent to collaborators at the latitude of best adaptation for evaluation. This would result in greater precision in genetic studies since all seedlings of a progeny could be evaluated.

This study deals with the potential of selecting for CR on the basis of time of growth cessation in low CR peaches and nectarines. Our hypothesis was that sequence of growth cessation would show a negative relationship to CR (9).

Materials and Methods

The ability to pre-select for CR in peach by observing GC under shortening daylengths was investigated using 864 seedlings from 26 families and 6 cultivars at the University of Florida, Gainesville. The seedlings, which ranged from 125 to 475 chill units (CU), were produced by crossing 4 pollen parents with 19 seed parents (Table 1). The CR of the 6 cultivars ranged from 50 to 650 CU (Table 2). 'FlordaGrande', 'Maravilha' 'San Pedro', and 'Flordaking' all resulted from the University of Florida breeding program. 'Sunfre' was developed at USDA in Fresno, California and 'June Gold' was developed by Armstrong Nursery in California.

Crosses were made in January and February of 1983. Fruit were harvested in May and the seeds were removed and stratified. Resulting seedlings were planted in the fruiting

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Table 1. Estimated chilling requirement (CR) and days to growth cessation (GC) after August 29 for some Florida low chilling peach and nectarine families.

Cross	Progeny CR mean	(chill units) range	Progeny GC (days) mean	range
FL 0-3 x FL 9-4	268	150 - 375	9.7	1 - 28
FL 0-4 x FL 7-7	286	250 - 375	15.5	7 - 21
FL 0-4 x FL 9-4	339	250 - 450	13.5	1 - 21
FL 1E-138 x FL 9-4	231	125 - 450	12.8	1 - 21
FL 3-4 x FL 0-2	248	125 - 350	13.9	1 - 42
FL 3-4 x FL 7-7	277	150 - 375	15.2	1 - 42
FL 3-4 x FL 9-4	298	250 - 350	16.2	1 - 28
FL 5-15 x FL 0-2	234	125 - 350	15.3	1 - 42
FL 5-15 x FL7-7	310	125 - 475	16.9	7 - 42
FL K5E-15 x FL 0-2	303	150 - 375	13.4	1 - 21
FL K5E-15 x FL 7-7	319	150 - 450	14.2	1 - 35
FL 5-18 x SH[z]	334	125 - 450	16.6	1 - 28
FL 5-19 x SH	357	250 - 450	11.9	1 - 42
FL 5-20 x SH	355	125 - 450	20.2	1 - 21
FL 7-11 x FL 0-2	341	275 - 375	28.9	14 - 42
FL 9-10 x FL 9-4	240	125 - 325	13.1	1 - 28
FL 9-11 x SH	278	150 - 350	15.4	1 - 35
FL 9-14 x FL 7-7	234	175 - 325	22.7	14 - 28
FL 9-14 x FL 9-4	259	150 - 350	12.2	7 - 21
FL 9-15 x FL 9-4	316	225 - 375	12.4	1 - 28
FL 9-15 x SH	294	175 - 425	15.3	1 - 35
FL 9-16 x FL 7-7	360	225 - 450	20.7	1 - 42
FL 9-16 x FL 9-4	341	275 - 450	13.1	1 - 21
FL 9-20 x FL 9-4	303	250 - 325	13.3	7 - 21
SR[y] x FL 9-4	329	275 - 425	17.7	1 - 21
SR x SH	342	275 - 450	14.9	1 - 28
			r = 0.32**	

[z]SH = Sunhome nectarine
[y]SR = Sunripe nectarine
**correlation value for n = 864, significant at 0.01 level

Table 2. Days to growth cessation (GC) after August 29 in 6 peach cultivars representing a range in chilling requirement (CR).

	CR Shoot	Days to GC A	B	C	D	E	Mean days to GC
FlordaGrande	50	15	22	22	22	33	23
Maravilha	225	22	15	22	25	15	20
San pedro	350	33	18	18	15	11	19
Flordaking	425	26	29	13	13	26	21
Sunfre	550	8	8	18	18	18	14
June Gold	650	8	8	8	8	8	8
				r = -0.58**			

**correlation value for n = 30, significant to 0.01 level.

nursery (16) in September 1983 and evaluated for GC in autumn 1984 and CR in spring 1985. Seedlings were visually rated for GC once a week starting August 30, 1984. Estimates were made for day of growth cessation. Three terminal shoots were observed on each seedling and GC was considered to have occurred when 2 of the shoots visually ceased producing leaves. Growth cessation was observed in all individuals before temperatures below 7°C occurred. The seedlings were classified as to CR by time of bloom in reference to cultivars of known CR. Reference cultivars used were 'Okinawa' 150 CU, 'Sunred' 250 CU, 'Early Amber' 350 CU, and 'Sunlite' 450 CU. Chilling requirement of the parents was also determined similarly. Time of peach bloom under north central Florida conditions is determined primarily by CR completion rather than difference in heat requirement. The range in bloom dates at Gainesville is mid-January to mid-March for peach cultivars of 100 to 650 CU, respectively. Peach cultivars of 200 to 400 CU bloom together in north Florida, cultivars of 400 to 600 CU bloom together in central Georgia, and all cultivars tend to bloom together in northern states where CR is met for each cultivar before heat units began accumulating in spring. The degree of lateness in bloom is this equated to the degree in inadequate chilling.

Growth cessation and CR in the 6 cultivars were determined in a similar manner as the seedlings. Trees of the 6 cultivars on a root-knot nematode resistant rootstock were 3 to 5 years old and uniform in vigor. They were given the same cultural practices. On August 13, 1984, 5 actively growing shoots approximately 2 m high and equidistant around a representative tree of each cultivar were selected and marked. Visual observations were made starting August 29 and the day of GC was estimated for each shoot.

The SAS computational package was used to obtain correlations and a regression (SAS Institute Inc., Cary NC). The CORR procedure (15) was used to determine the relationship between GC and CR in both seedlings and cultivars. The general linear model (GLM) procedure (5) was used to obtain the midparent-offspring regression coefficient which was used as an estimate of h^2 for CR (4). Since progeny population size differed between crosses, the regression was weighted by the number of seedlings per progeny.

Results and Discussion

Relationship Between GC and CR. A low, but significant, positive correlation ($r = 0.32^{*}$) was found between GC and CR for individual seedlings in the populations. Thus, lower CR seedlings tended to terminate growth earlier than higher CR seedlings. This is opposite of the trend expected in peach and reported in other species (2, 12, 13, 17, 19,). Conversely, a significant negative correlation ($r = -0.58^{**}$) was found between CR and days to GC for the 6 cultivars. Thus, cultivars with a high CR tended to terminate growth earlier than cultivars with a low CR. This correlation is lower than the correlations of -0.89, -0.71, and -0.82 between GC and latitude of origin for 3 species of *Populus* (13).

Several explanations are plausible as to why the seedling population showed a trend opposite that found in budded trees and in mature seedlings of other species. The peach seedlings demonstrated considerable variation in vigor with stem diameters ranging from 4 to 26 mm. A significant positive correlation ($r = 0.43^{**}$) was found between stem diameter (SD) and GC with larger seedlings terminating growth later than smaller seedlings. A low, significant positive correlation ($r = 0.12^{**}$) between SD and CR was also found. Although the relationship between CR and vigor is unknown it is possible that this interaction is partially responsible for the trend observed. Since the seedlings were only 14 months old at GC evaluation many of them were juvenile or in the transition period between juvenile and adult. This may have had an effect on GC under decreasing photoperiods since juvenile deciduous plants are often more vigorous and exhibit delayed leaf drop as compared to adults.

The limited range of CR of the 6 cultivars may be responsible for the cultivar correlation obtained (r = -0.58**) being lower than those reported in *Populus* (13). The range of CR for the 6 cultivars (50-650 CU) was about half of the range existing in peach (0-1150$^+$ CU). The 6 cultivars are adapted from 26 to 32 degrees latitude in the southeastern US, lowest to highest CR respectively, while the *Populus* examined (13) had a distribution range from 34 to 61 degrees latitude. It is possible that by examining a wider range of CR, a correlation of higher magnitude would be obtained. In fact, the cultivars, which had a wider CR range, showed a relationship between CR and GC that was more in line with what has been found in other species than the seedlings, which had a narrow CR range.

h^2 Estimate for CR.

The regression of progeny means on the mid-parent CR values gave a h^2 of 0.93 ± 0.14. This estimate was higher than the h^2 value of 0.49 obtained in another low CR peach population (14). We recognize these h^2 values are valid only for the population under study; however, both are high indicating that additive gene action is the primary component in CR inheritance. Our h^2 value for CR is similar to h^2 values for other CR relatéd observations such as time of bloom in prune (h^2 = 0.86) (7) and time of leaf bud break in walnut (h^2 = 0.96) (6).

Conclusions

A negative relationship between CR and time of GC in the autumn was found for mature trees indicating that an estimate of CR could be made on the basis of time of GC in mature trees. However, the relationship was not evident in young seedlings and pre-selection of individual seedlings for CR by observing GC at the end of growing season was not feasible. Seedling juvenility and vigor had a larger influence on GC than the CR of the seedling. This technique might be partially effective for screening segregating populations derived from crosses of parents with large differences in CR, since the CR range would be much greater than the range used in this study.

The relationship between days to GC and CR found in the 6 cultivars has interesting implications for biannual peach production in tropical regions. Extremely low CR cultivars should continue growth and flower bud set throughout the year even under the relatively constant short photoperiods of the tropics.

The high h^2 estimate for CR in peach indicates that rapid progress is possible in breeding high chilling peach and possibly other deciduous species for subtropical latitudes, provided that a cross-compatible source of low-chill germplasm is available.

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Book Review

Fruits of India Tropical and Subtropical, Edited by T. K. Bose, ppl 658, cloth bound, published by Naya Prokash, 206 Bidhan Sarani, Calcutta 700 006 India, cost Rs 600.00

This book contains chapters on each of the following crops: Mango, Banana, Citrus, Grape, Guava, Pineapple, Papaya, Coconut, Litchi, Cashew, Sapota, Avocado, Custard Apple, Jackfruit, Bael, Fig, Ber, Pomegranate, Loquat, Phalsa, Date Palm, Jamun and Aonla. Each chapter begins with a picture of the crop and describes the origin, uses, varieties, soil and climatic requirements, propagation, planting, fertilization, flowering and growth characteristics. The nutritive value of each crop is defined and interest is added by including local uses for not only the fruit but other parts of the plant as well. Although many of the cultural recommendations are those currently used in India, the detailed information has broader applications to other areas with climate permitting culture of these fruit crops. This book provides a fascinating insight into many fruit plants not commonly cultured and will be of interest and value to pomologists.