Effect of Rootstock on Bloom Periods of Pear Trees[1]

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Abstract. A 4-year study of the bloom periods of pear trees with different types of rootstocks indicates that, under the range of chilling conditions characteristic of California's major pear districts, rootstock has little or no influence on scion chilling requirements.

Introduction

COMMON varieties of *Pyrus communis* L. normally open their buds under California conditions after about 1200 to 1500 hr at or below 45°F. Important in satisfying the chilling requirements of these and other deciduous fruit trees are the continuity of chilling temperatures, the periods when they occur, and the total accumulation of chilling hours. The adequacy of winter cold in ending the rest period may be modified by the intensity of sunlight, fog or cloud, wind, and tree condition (4). Following winters that fail to provide sufficient chilling, these trees may show delayed and prolonged bloom periods, dead flower buds, fewer flowers, delayed foliation, and reduced vigor. The chilling requirements prevent commercial production of pears at low elevation in southern California and in areas of warmer winters as far north as central California.

Differences in time of blossoming and foliation indicate differences in the chilling required to break the rest period (4, 6, 10). Following winters with enough chilling hours for 'Bartlett' buds to open normally, 'Bartlett' and 'Winter Nelis' trees bloom and foliate at about the same time. 'Winter Nelis' has a somewhat lower chilling requirement than 'Bartlett', however, and after mild winters may bloom a week to 10 days before 'Bartlett' (4, 6). When late spring frosts occur, such early bloom has resulted in the loss of most of the 'Winter Nelis' crop to the last killing frost while the unopened blossoms of adjacent 'Bartlett' trees were not damaged. Hence, the greater chilling requirement of 'Bartlett' may be beneficial in the Sierra Nevada foothills, where late spring frosts are perennial hazards, and detrimental in San Joaquin County, where the mild winters often provide inadequate chilling for this variety.

Movement of the rest influence through graft unions was demonstrated by Chandler (3), who grafted fully chilled apple scions on young trees still in the rest period and found that growth of the scion buds was stopped by rest imparted from the tree. Westwood and Chestnut (11) found that inadequately chilled 'Bartlett' buds produced more growth when budded into 'Bartlett' trees with *P. calleryana* roots than when left on own-rooted 'Bartlett' trees. Further, growth from inadequately chilled 'Bartlett' buds was greater on the same branch with growing *P. calleryana* shoots than when no *calleryana* shoots were present. They concluded that some of the rest influence in *Pyrus* can be translocated and that the chilling requirement of 'Bartlett' was lowered by growing it on a rootstock with a low chilling requirement. Brown et al. (2) administered various periods of winter chilling to own-rooted 'Bartlett', 'Bartlett' on *P. calleryana* seedling roots, and 'Bartlett' on quince roots. From percentages of buds opening and length of shoot growth following treatments providing inadequate chilling, they concluded that chilling requirement was somewhat greater for 'Bartlett' on *P. calleryana* than for 'Bartlett' on quince or 'Bartlett' roots.

If the rootstock appreciably affects the chilling requirement of the scion variety, 'Bartlett' production might be extended into areas where mild winters are the limiting factor. Also, rootstocks that would increase, rather than reduce the chilling requirement of 'Bartlett' would be preferred in spring frost hazard areas.

Any appreciable effect of rootstock on scion chilling requirement should be manifested in the bloom period. Hatton and Grubb (8) reported that different rootstocks caused 'Lane's Prince Albert' apple to vary as much as 7 days in the first opening of flowers and 4 days in full bloom. With European plums, Hatton et al. (7) reported that in some seasons the opening of the first flowers of 'Victoria' differed by nearly a week on 'Pershore' and 'Mussel', *P. domestica,* stocks from that on 'Brussel', *P. domestica,* and Myrobalan, *P. cerasifera.* Time of blossoming of the rootstock appeared to be unrelated to its influence on any particular scion, since the late-blossoming 'Pershore Egg' stock appeared to accelerate time of flowering, whereas the early-flowering Myrobalan delayed it. Day (5) noted no differences in the blooming dates of 'Bartlett' with *P. pyrifolia* seedling versus *P. communis* seedling rootstocks.

Recently established pear rootstock plots afforded an opportunity to study the effect of rootstock on the bloom period of the scion variety.

Materials and Methods

The study was conducted in pear rootstock plots in the University of California orchards at Davis and Winters and in the George H. Volz orchard near Gold Hill, California. The scion-rootstock combinations and the non-topgrafted trees studied are shown in Tables 1 (Davis), 2 (Winters), and 3 (Gold Hill). The trees at Davis were planted in 1961 and 1962, those at Winters in 1961 and 1963,

Table 1. Bloom periods of young pear trees with different *Pyrus* rootstocks. Davis, California, 1965–1966.

Type of tree		Bloom period					
		1965			1966		
Scion	Rootstock	First	Full	Last	First	Full	Last
Bartlett	Bartlett seedlings	Mar 22	Apr 2	Apr 7	Mar 28	Apr 1	Apr 5
Bartlett	Winter Nelis sdlg	Mar 22	Apr 2	Apr 6	Mar 28	Apr 1	Apr 5
Bartlett	*P. calleryana* sdlg	Mar 22	Apr 2	Apr 6	Mar 28	Apr 1	Apr 6
Bartlett	Old Home, own-rooted	Mar 22	Apr 2	Apr 7	Mar 28	Apr 1	Apr 6
Bartlett	*P. serotina* sdlg	Mar 22	Apr 2	Apr 7	Mar 28	Apr 1	Apr 7
Bartlett	*P. ussuriensis* sdlg	Mar 22	Apr 2	Apr 7	Mar 28	Apr 1	Apr 6
Winter Nelis	Bartlett seedlings	Mar 22	Apr 2	Apr 6	Mar 25	Mar 30	Apr 2
Winter Nelis	Winter Nelis sdlg	Mar 21	Apr 2	Apr 7	Mar 25	Mar 30	Apr 3
Winter Nelis	*P. calleryana* sdlg	Mar 23	Apr 2	Apr 6	Mar 24	Mar 29	Apr 4
Winter Nelis	Old Home, own-rooted	Mar 22	Apr 1	Apr 6	Mar 24	Mar 29	Apr 4
Winter Nelis	*P. serotina* sdlg	Mar 22	Mar 30	Apr 6	Mar 24	Mar 30	Apr 5
Winter Nelis	*P. ussuriensis* sdlg	Mar 22	Apr 1	Apr 6	Mar 24	Mar 30	Apr 4
Hardy	Bartlett seedlings	Mar 21	Apr 2	Apr 7	Mar 24	Mar 30	Apr 3
Hardy	Winter Nelis sdlg	Mar 22	Apr 2	Apr 6	Mar 24	Mar 30	Apr 2
Hardy	*P. calleryana* sdlg	Mar 23	Apr 2	Apr 7	Mar 25	Mar 30	Apr 4
Hardy	*P. serotina* sdlg	Mar 24	Apr 3	Apr 7	Mar 24	Mar 30	Apr 5
Non-topgrafted							
Bartlett, own-rooted		Mar 23	Mar 29	Apr 6	Mar 28	Mar 31	Apr 5
P. calleryana seedlings		Mar 3	Mar 8	Mar 16	Mar 4	Mar 15	Mar 29
Old Home, own-rooted		Mar 22	Apr 2	Apr 8	Mar 24	Mar 30	Apr 6
P. serotina seedlings		Mar 10	Mar 19	Apr 1	Mar 12	Mar 21	Mar 29
P. ussuriensis seedlings		Mar 5	Mar 11	Mar 18	Mar 4	Mar 9	Mar 21

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Table 2. Bloom periods of young pear trees with different *Pyrus* and *Cydonia* rootstocks. Wolfskill Experimental Orchard, Winters, California, 1967–1968.

Type of tree		Bloom period					
		1967			1968		
Scion	Rootstock	First	Full	Last	First	Full	Last
Bartlett	Bartlett seedlings	Mar 22	Apr 7	Apr 14	Mar 11	Mar 25	Mar 29
Bartlett	Winter Nelis sdlg	Mar 21	Apr 7	Apr 14	Mar 12	Mar 25	Mar 30
Bartlett	Old Home[a]	Mar 22	Apr 7	Apr 13	Mar 11	Mar 24	Mar 29
Bartlett	Old Home[b]	Mar 23	Apr 8	Apr 15	Mar 11	Mar 25	Mar 29
Bartlett	Province quince	Mar 23	Apr 8	Apr 15	Mar 11	Mar 26	Mar 30
Bartlett	*P. betulaefolia* sdlg	Mar 22	Apr 7	Apr 14	Mar 11	Mar 25	Mar 29
Non-topgrafted							
Bartlett[a]		Mar 22	Apr 7	Apr 14	Mar 12	Mar 26	Mar 30
Winter Nelis[a]		Mar 20	Mar 29	Apr 4	Mar 11	Mar 23	Mar 29

[a]Own-rooted.
[b]On Angers quince.

and those at Gold Hill in 1962 and 1963. Trees and rootstocks designated as own-rooted were developed from hardwood cuttings. The number of trees of each type were 20 to 49 at Davis, 19 to 38 at Winters, and 10 to 20 at Gold Hill.

The bloom dates were determined from notes taken at approximately 3-day intervals. The dates of first, full, and last bloom shown in the tables are averages of 10 trees of each type. A tree was considered in first bloom when 1 to a few clusters showed open flowers, in full bloom when the number of flowers in the petal-fall stage approximately equaled those in the unopened "popcorn" stage, and at last bloom when approximately 95 percent of the flowers had reached petal fall. The trees at Davis were studied in 1965 and 1966, those at Gold Hill in 1967, and those at Winters in 1967 and 1968.

Results and Discussion

Table 1 shows the bloom periods of the trees at Davis. Trees of a single variety bloomed at about the same time regardless of rootstock. It seems logical to assume that any effect of the rootstock on chilling requirement of the scion variety would be most apparent after poor-chilling winters, when blossoming is delayed by the remaining rest influence. 'Bartlett' and 'Winter Nelis' would be useful since the time interval between the bloom periods of these varieties is greatest following the poorest chilling winters (4, 6). Records at Davis for the past 38 years show that the 22 years designated as good-chilling provided an average of 1553 hr of chilling temperatures (at or below 45°F) between September 1 and March 1. The other 16 years, with poor-chilling winters, averaged 1231 hr at 45°F or lower. During the critical December and January periods (2, 4, 10), the good-chilling winters provided averages of 470 and 498 chilling hours, respectively, versus 355 and 354 for the poor-chilling winters.

Between September 1, 1964, and March 1, 1965, at Davis, there were 1560 chilling hours. This was evidently sufficient for normal bud opening of 'Bartlett', since 'Bartlett' bloomed with 'Winter Nelis' and 'Hardy'. On the other hand, the winter of 1965–66 provided 1750 chilling hours, but the 'Bartlett' bloom was 3 or 4 days behind that of 'Winter Nelis' and 'Hardy'. The contrary response may have been due to differences in the continuity of chilling temperatures, shown to be important by Bennett (1) and Brown et al. (2). Variations in the amount of fog and the intensity of sunlight may have influenced the effectiveness of chilling. The monthly accumulations of chilling hours for November through February were respectively 256, 371, 535, and 331 in 1964–65, versus 196, 663, 472, and 300 in 1965–66. The milder weather in January and early February of 1966 may have nullified the effectiveness of the accumulated chilling hours to the extent that the chilling requirements of 'Bartlett' were not satisfied as completely as in the previous year, permitting the varieties with lower chilling requirements to bloom first.

There was no apparent effect of rootstock on bloom dates of the 3 varieties in either 1965 or 1966. Thus any influence of the rootstock on the chilling requirements was too slight to be manifested following winters that failed to separate the bloom periods of 'Bartlett' and 'Winter Nelis' by more than 3 or 4 days.

At Davis, the long-time average lengths of the bloom periods of 'Bartlett', 'Winter Nelis', and 'Hardy' were respectively 17, 13, and 15 days (6). In 1965 the length of the bloom periods of each of the 3 varieties was approximately 15 days. In 1966, however, the bloom period of 'Bartlett' lasted only about 9 days, and those of 'Winter Nelis' and 'Hardy' about 11 days. The shorter bloom periods were evidently due to rapid development under the high temperatures that occurred during the last 3 days in March and the first week in April of that year.

Among the trees not topgrafted, the own-rooted 'Bartlett' and 'Old Home' trees bloomed with the varieties topgrafted on the different types of rootstocks. The *P. calleryana* Decne., *P. ussuriensis* Maxim., and *P. serotina* Rehd. (*P. pyrifolia* Burm.) seedlings respectively started blossoming ahead of 'Bartlett' by 19, 17, and 12 days in 1965, and by 24, 24, and 16 days in 1966. Thus, following the less effective chilling conditions of 1965–66, these oriental species, with their lower chilling requirements, bloomed earlier in relation to 'Bartlett' than in 1965. In 1966, oriental seedlings had longer blossoming periods than the varieties of *P. communis* because they bloomed early enough to avoid having their blossoming periods cut short by the hot weather.

Evidently under California conditions, seedlings of these oriental species invariably bloom ahead of 'Bartlett' and other common varieties of *P. communis*. In addition to having lower chilling requirements, the oriental species may reach a more advanced stage of flower bud development dur-

Table 3. Bloom periods of Bartlett pear trees with different *Pyrus* rootstocks. Gold Hill, California, 1967.

Type of tree		Bloom period		
Scion	Rootstock	First	Full	Last
	Young trees			
Bartlett	Bartlett seedlings	Apr 8	Apr 23	May 15
Bartlett	Winter Nelis seedlings	Apr 8	Apr 23	May 15
Bartlett	Old Home[a]	Apr 8	Apr 22	May 15
Bartlett	Old Home × Farmingdale[a]	Apr 9	Apr 26	May 15
Bartlett	*P. calleryana* sdlg	Apr 7	Apr 22	May 18
Bartlett	*P. betulaefolia* sdlg	Apr 8	Apr 22	May 14
Bartlett	*P. betulaefolia*[a]	Apr 8	Apr 22	May 16
Non-topgrafted				
Bartlett, own-rooted		Apr 9	Apr 25	May 16
Mature trees (nearby orchard)				
Scion	Rootstock			
Bartlett	*P. communis* sdlg	Apr 7	Apr 20	May 11
Winter Nelis	*P. communis* sdlg	Mar 28	Apr 5	Apr 15

[a]Own-rooted.

ing late summer and autumn of the year prior to opening and may proceed more rapidly during warm periods in winter. Herbst and Weger (9) reported that the time when a pear variety flowers in Western Germany is determined by the number of hours, calculated from midwinter, during which the temperature exceeds 43°F. The number varies from variety to variety. Hence, the variety requiring the least number of degree-hours would be the first to flower. Perhaps fewer hours at this or some other threshold temperature are required to bring the oriental pears into blossoming than for varieties of *P. communis.*

Table 2 shows the bloom periods of the trees at the Wolfskill station near Winters. Regardless of rootstock, the bloom periods of the 'Bartlett' trees did not vary more than a day or 2 in either 1967 or 1968. The plot is near the foothills on the west side of the Sacramento Valley, at about 140 ft elevation. The higher elevation means less exposure to chilling fog than at Davis. Thermograph records at the Wolfskill station showed that the winter of 1966–67 was in the poor-chilling category, providing 1058 hours at or below 45°F. During December, 1966, 428 chilling hours were accumulated, but January, 1967, was unusually mild, providing only 267 chilling hours. The winter of 1967–68 provided 1250 chilling hours, with respectively 468 and 525 hr accumulated in December and January.

Following the mild winter of 1966–67, the 'Winter Nelis' trees started blooming 2 days before 'Bartlett' and reached full bloom 9 days ahead. In 1968, after a colder winter, the respective intervals were 1 and 3 days. It was assumed that the winter of 1966–67 provided a more favorable situation than the winter of 1967–68 for determining any effect of rootstock on the chilling requirement of 'Bartlett'. The range of bloom among trees with the different stocks, however, was about the same in 1967 as in 1968.

Based on average dates of bloom, *P. betulaefolia* trees have a smaller chilling requirement than the common varieties of *P. communis,* but a greater chilling requirement than *P. calleryana.* At Davis, during 8 years, non-topgrafted *P. calleryana* trees started blooming and reached full bloom before 'Bartlett' by an average of 24 and 21 days, respectively. In the same years, *P. betulaefolia* trees reached first and full bloom respectively 10 and 8 days before 'Bartlett'.

The bloom periods of 'Bartlett' trees with the different rootstocks at the Gold Hill plot in 1967 showed no striking differences (Table 3). The trees showed moderate symptoms of delayed flowering and foliation due to insufficient chilling, and under the cool, rainy weather that prevailed during April, the 'Bartlett' bloom was greatly prolonged. The plot is at approximately 1900 feet elevation, above the Sacramento Valley fog belt, and thus more likely to suffer from inadequate winter chilling than trees in the valley. There was no thermograph near the plot. Records at Davis, at elevation 50 ft, and at the Wolfskill station near Winters, elevation 140 ft, showed respectively 1414 and 1058 hr at or below 45°F between September 1, 1966, and March 1, 1967. January, 1967, was mild, providing only 387 chilling hours at Davis and 267 at Winters.

Chilling temperatures apparently were less effective at Gold Hill than at Davis or Winters since mature 'Winter Nelis' trees in the neighboring orchard started blooming 10 days before mature 'Bartlett' (Table 3) and reached full bloom 15 days ahead. This also indicated that the rest period of the 'Bartlett' buds was not completely broken in the Gold Hill area. Hence, the conditions were good for detecting any influence of rootstock on the chilling requirements of 'Bartlett'. 'Bartlett' on *P. calleryana* seedlings started blooming a day or 2 earlier than 'Bartlett' on the other stocks, which may indicate that the *P. calleryana* stock reduced the scion chilling requirements slightly. The 'Bartletts' on *P. calleryana,* however, reached full bloom at the same time as 'Bartlett' on 'Old Home' or *P. betulaefolia* seedlings. The 'Bartlett' on the 'Old Home' × 'Farmingdale' clone and the own-rooted 'Bartlett' reached full bloom 3 or 4 days later than 'Bartlett' on the other stocks, but these trees seemed to have a greater proportion of axillary flower clusters, which tend to open more slowly, especially following mild winters, than those borne terminally.

The 4-year study covered about as wide a range of chilling conditions as usually occurs in California's major pear districts. The bloom dates indicate that, under the range of environmental conditions occurring in these districts, the rootstock does not appreciably influence the chilling requirements of the scion variety. This corroborates accumulated experience, since those concerned with pear culture have not attributed differences in bloom dates to rootstocks. Areas with winters too mild for commercial pear production might manifest a more subtle relationship between the rootstock and scion variety in regard to chilling response, as noted under treatments of inadequate chilling (2, 3, 11).

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