FRUIT SET AND THE EFFECTIVE POLLINATION PERIOD IN APPLE AND PEAR AS AFFECTED BY BLOOM AND POST-BLOOM TEMPERATURE.

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Abstract

Under controlled temperature conditions fruit set and the effective pollination period (EPP) of pear cv. Doyenné du Comice and apple cv. Golden Delicious were studied at 4 temperature regimes, i.e. 13°(bloom)-13°C (post-bloom), 13-17, 17-17, and 17-13. The post-bloom temperature was applied from 1 day after the end of bloom. Fruit set was determined 3 and 6 weeks after bloom. Fruit set at 3 weeks was very high in pear and apple. There were hardly any differences between the various temperature regimes. A severe fruit drop occurred between 3 and 6 weeks after bloom when post-bloom temperature was high. The effect of bloom temperature on fruit set was very small. The data for pear indicate that the EPP is extended somewhat at the high bloom temperature. In apple the EPP was about the same in all treatments.
The data suggest that final fruit set in Doyenné du Comice as well as in Golden Delicious is mainly determined by the post-bloom temperature. Bloom temperature is not relevant as long as pollination and the EPP do not limit fruit set.

Additional index words: *Pyrus communis* L., *Malus domestica* Borkh.

1. Introduction

The view that temperature is an important factor determining fruit set in perennial fruit crops is widely accepted. However, evidence from experiments where trees were exposed intentially to different temperatures under controlled conditions is scarce. Abbott (1971) and Jackson *et al.* (1983) showed a promotion of fruit set at low temperatures during bud development prior to bloom but the reverse was also found (Tromp, 1986). In a few recent experiments on apple and pear Tromp (1994) studied the effect of autumn and spring temperature on fruit set and the 'effective pollination period' (EPP), i.e. ovule longevity minus the time between pollination and fertilization (Williams, 1965). Different autumn temperatures were not effective. In pear, fruit set was lower and the EPP shorter at 17° than at 13°C during the bloom period. In apple, at a bloom temperature of 19°C, the EPP was extended and fruit set promoted when the temperature was lowered to 13°C just after bloom.

The aim of the present 2 experiments on apple and pear was to further study, under controlled temperature conditions, the effect of a few bloom and post-bloom temperature treatments on fruit set and the EPP.

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2. Material and methods

For the experiments were used 9-year-old potted pear trees cv. Doyenné du Comice (rootstock Quince MC) and 5-year-old potted apple trees cv. Golden Delicious (rootstock M.9). Pot volume was 25 and 16 l for pear and apple, respectively. Two identical controlled environment day-light rooms were available. Relative air humidity was 70% at each applied temperature; thus the vapour pressure deficit of the air was not the same at the different temperatures.

2.1. Experiment 1 (Doyenné du Comice)

In March, 4 groups of 6 trees were forced into bloom at 17°C. Shortly before bloom for 2 groups temperature was lowered to 13°C. Before bloom, 30 clusters per tree were thinned to 3 equivalent flowers each. All other flower clusters were removed. After emasculation, at the first day the flowers were open (day 0) and further at day 1, 2, 4, and 6, 5 clusters per tree were hand pollinated (pollen from cv. 'Conference'). The 5 remaining clusters were not pollinated. From 1 day after the last flowers were pollinated one 17°C-group of 6 trees was exposed to 13°C and one 13°C-group to 17°C. The remaining trees were kept at 17° and 13°C, respectively. Fruit set for each individual flower cluster (including the unpollinated) were recorded 3 and 6 weeks after pollination, and at harvest. At harvest the number of seeds per fruit was determined.

2.2. Experiment 2 (Golden Delicious)

For this experiment 4 groups of 5 trees were available. The experimental procedure was exactly the same as in experiment 1, excepted that per tree 25 clusters were used and that pollination occurred at day 0, 2, 4 and 6.

All fruit set data were subjected to analysis of variance, followed by Student's t-test (P=0.05). Angular transformation of the data was performed. The Tables contain the transformed data.

3. Results

3.1. Doyenné du Comice

When the flowers were pollinated shortly after opening (Day 0 and 1), fruit set at 3 weeks after bloom was very high and differences between the various temperature regimes, if any, were small (Table 1). Fruit set decreased when pollination was delayed. That decrease was initially most marked at the high post-bloom temperature (regimes 13-17 and 17-17) but later (Day 4 and 6) fruit set was also rather poor in the 17-13 regime. In general the highest set was found at the bloom temperature of 13°C especially when that temperature was also maintained after bloom.

Table 1 shows that in the 13-17 and 17-17 treatments a severe fruit drop occurred between 3 and 6 weeks after bloom when pollinated at Day 0, 1, and 2, but that

hardly any fruits had dropped at Day 4 and 6. As a result, fruit set after 6 weeks at the regimes 13-17 and 17-17 was clearly lower than at the other regimes, in particular when pollinated early, and, in addition, was little affected by time of pollination. When post-bloom temperature was low (regimes 13-13 and 17-13) set decreased when pollination was postponed. Especially a marked reduction occurred at Day 4 and 6 in the 17-13 regime.

There was no further fruit drop between week 6 and final harvest. Apart from the 13-13 regime at 3 weeks after bloom, fruit set was very low for the unpollinated flowers; the very few fruits that set initially dropped later on. The number of seeds per fruit was rather high, but it was neither influenced by bloom or post-bloom temperature nor by time of pollination (Table 1).

3.2. Golden Delicious

Fruit set at 3 weeks after bloom appeared to be extremely high at all temperature regimes. There was no difference between the regimes and not any effect of time of pollination could be shown (Table 2). At 6 weeks after bloom the situation had changed appreciably. As was also found for pear a rather severe fruit drop occurred especially in the 13-17 and in the 17-17 regime resulting in lower fruit set values than found for the the other regimes. In the 17-13 regime fruit set decreased somewhat when pollination was delayed, but for the rest there was hardly any influence of time of pollination. Between week 6 and final harvest a further fruit drop occurred when the post-bloom temperature was low (13-13 and 17-13). As a consequence at final harvest the differences in fruit set between the various regimes were relatively small. In the 13-13 and 17-13 regime a delay in pollination reduced set. For the unpollinated flowers fruit set initially was rather high especially when post-bloom temperature was 13°C. In the course of time most fruits dropped but the harvest data still suggest a slightly better set when post-bloom temperature was low. The number of seeds per fruit was rather variable. Broadly speaking, the low post-bloom temperature was reflected in a somewhat lower seed number (Table 2). Furthermore, seed number was reduced at the later dates of pollination. It was especially low at Day 6 in the 13-13 and the 17-13 regime. The few fruits that were left in the 'no pollination' treatment did not contain or hardly contained any seeds.

4. Discussion

When for Doyenné du Comice bloom and post-bloom temperature were the same (regimes 13-13 and 17-17) fruit set was markedly lower for the lower temperature, irrespective the time of pollination. A similar pattern was found for Golden Delicious although the differences between temperatures were much less pronounced. These results confirm recent findings of Tromp and Borsboom (1994) also for 'Doyenné du Comice'. For apple Lu and Roberts (1952) found a much lower set in trees kept in a warm than in a cool greenhouse during flowering and a few weeks thereafter. In experiments of Grauslund and Hansen (1975) fruit set in some cultivars decreased with an increase in bloom temperature in the range of 11° to 19°C. A similar result was obtained for apple by Westphal-Stevels (1970) for a

range of five temperatures (12° to 24°C) given from the onset of bloom until the end of the naturel drop period. The conclusion that lower bloom temperatures favour fruit set lies beforehand. However, this conclusion is premature since it disregards the effect of post-bloom temperature. As Table 1 clearly shows for Doyenné du Comice the differences in fruit set between regimes 13-13 and 17-17 are almost completely due to the post-bloom temperature and not to the bloom temperature, at least when pollination is not delayed too much. The same holds for Golden Delicious (Table 2), but the pattern is less clear due to the generally smaller differences between treatments. The negative effect of higher post-bloom temperatures on fruit set in apple is in agreement with results of Lu and Roberts (1952), Grauslund and Hansen (1975), Grauslund (1978) and Tromp and Borsboom (1994). For pear there is no information available. Thus, the present data suggest that provided pollination is not limiting, fruit set is mainly determined by post-bloom temperature and only in minor degree by bloom temperature .

It is questionable whether also in a lower temperature range bloom temperature is not relevant for fruit set. Wilson and Williams (1970) stated that in cool springs the EPP is the limiting factor for fruit set in fruit trees rather than the actual pollination. However, it is quite plausible that at higher temperatures pollination becomes the limiting factor for fruit set, in particular when pollination is carried out shortly after flower opening. In this respect it is noteworthy that in Doyenné du Comice fruit set is reduced when pollination is postponed to Day 4 or Day 6 indicating that the EPP is becoming the limiting factor for fruit set. Since that reduction is more marked at 17° than at 13°C (i.e. the EPP is shortened at the higher temperature), it may be concluded that bloom temperature only is not important for fruit set as long as the EPP is not the limiting factor.

The shorter EPP at 17° than at 13°C as found in the present study and by Tromp and Borsboom (1994) for Doyenné du Comice does not fit in the original EPP-concept which assumes that the EPP is shortened with an increase of temperature. Probably, contradictory to the situation at lower temperatures, at higher temperatures the increase in the rate of pollen tube growth does not keep pace with decrease in ovule viability. The slightly reduced fruit that may have occurred set at the high bloom temperature for Day 4 and 6 is not reflected in a clear reduction of number of seeds per fruit (Table 1). In Golden Delicious final fruit set was the same in the various treatments indicating that the EPP was not affected. However, as shown in Table 2, time of pollination did affect seed number. Why in the 13-13 treatment seed number was lower than in the other treatments is not clear.

In contrast to the situation for Doyenné du Comice, a marked parthenocarpic fruit set occurred in Golden Delicious. Just as found for 'normal' set most fruit kept on the tree at the lower post-bloom temperature.

In general in all treatments fruit set was high in the first few weeks after bloom. The effect of post-bloom temperature was most pronounced between 3 and 6 weeks after pollination. The view that fruit drop is brought about by competition by growing shoot tips and nearby fruitlets is widely accepted. Grauslund (1978) removed shoots of trees kept at a range of temperatures and found an enhanced set at each temperature. However, it is very unlikely that in the present experiment growth vigour controlled the degree of fruit set (growth data not given). It may be possible that temperature directly affects the various processes.

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Table 1. The effect of bloom and post bloom temperature, and time of pollination (days after flower opening) on fruit set (% of treated flowers) 3 and 6 weeks after pollination and on number of seeds/fruit at harvest in Doyenné du Comice.

Temp. (°)		Time of pollination (day)						
Bloom	Post bloom	0	1	2	4	6	-	LSD (P=0.05)
		Fruit set, week 3						
13	13	90.0	84.9	83.0	70.0	49.7	32.5	26.9
13	17	83.0	77.6	65.9	45.4	36.6	8.6	22.9
17	17	73.9	68.1	54.8	31.5	19.2	6.1	29.8
17	13	80.7	76.7	71.6	36.4	21.5	9.7	21.4
LSD	(P=0.05)	25.0	26.5	35.7	30.0	38.3	31.6	
		week 6						
13	13	76.5	73.4	76.4	63.4	49.7	7.7	24.6
13	17	28.2	31.4	29.1	36.8	31.3	2.6	19.1
17	17	33.8	31.5	28.5	28.8	16.9	2.6	33.0
17	13	69.0	67.6	64.2	35.8	21.5	2.6	20.0
LSD	(P=0.05)	34.2	33.7	34.9	24.8	35.1	-[1]	
		Seeds/fruit at harvest						
13	13	7.5	8.1	8.2	8.1	8.1	-[1]	
13	17	8.1	8.1	7.6	8.0	7.8	-	
17	17	7.3	6.8	7.5	8.1	7.4	-	
17	13	7.6	7.8	7.6	8.1	6.2	-	

[1] not determined

Table 2. The effect of bloom and post bloom temperature, and time of pollination (days after flower opening) on fruit set (% of treated flowers) 3 and 6 weeks after pollination and on number of seeds/fruit at harvest in Golden Delicious.

Temp. (°C)		Time of pollination (day)					
Bloom	Post bloom	0	2	4	6	-	LSD (P=0.05)
	Fruit set, week 3						
13	13	90.0	86.9	90.0	90.0	81.6	11.0
13	17	86.9	81.6	74.4	78.5	33.5	21.3
17	17	76.6	81.6	82.2	61.5	36.6	23.1
17	13	86.9	86.9	82.7	83.9	64.5	15.4
LSD	(P=0.05)	12.6	19.5	25.8	16.3	27.2	
	week 6						
13	13	83.9	83.9	82.7	73.2	55.3	16.9
13	17	63.1	65.5	59.9	52.4	8.4	20.2
17	17	57.2	64.9	63.6	50.9	12.6	20.7
17	13	83.7	83.7	71.5	68.5	50.7	23.5
LSD	(P=0.05)	21.4	23.3	28.4	17.1	25.5	
	oogst						
13	13	71.0	74.6	71.4	49.4	26.1	23.2
13	17	60.4	67.5	57.8	50.9	3.1	18.9
17	17	57.2	61.2	62.7	50.9	11.4	20.9
17	13	77.6	74.9	56.9	53.7	25.7	26.5
LSD	(P=0.05)	25.3	28.1	31.9	18.5	23.4	
	Seeds/fruit at harvest						
13	13	4.8	4.8	4.2	2.4	0.0	
13	17	6.4	6.4	5.9	4.6	0.0	
17	17	5.6	7.0	5.9	5.2	0.4	
17	13	6.0	5.4	4.3	3.7	0.4	