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Effects of growth regulators on fruit set and June drop of pears and apples[1]

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Summary

To increase yields of pear and apple trees the growth regulators kinetin, gibberellin (A_3 and a mixture of A_4 and A_7), N-dimethylaminosuccinamic acid (Alar) and (2-chloroethyl)trimethylammonium chloride (CCC) were applied by spraying on blossoms or fruitlets and by injection into the trunk. Kinetin and particularly gibberellins were effective in stimulating fruit set in pears. Doyenné du Comice pear set more fruits with a mixture of gibberellin A_4 and A_7 than with gibberellin A_3.
Although the majority of stimulated fruits abscised during the June drop period, the crop was markedly increased. The growth retardants Alar and CCC were inactive in increasing fruit set, but prevented excessive drop of fruits when applied after a gibberellin application.

Introduction

Some auxins and gibberellin A_3 increase fruit set of pome fruits as reported for pears by Gorter and Visser (1958), Luckwill (1959), Modlibowska (1960) and Varga (1968), and for apples by Dennis and Edgerton (1962) and Varga (1966). The practical problems have not been solved, however. In many cases fruit set is satisfactory, but frequently the fruitlets are shed.
As there are indications (Varga, 1966) that A_3 may not be the most active of the gibberellins, a mixture of A_4 and A_7 was applied to induce fruit set. Kinetin was included because Pierik (personal communication) found that kinetin promoted the growth of fruits in vitro.
Fruits pass through a critical period in their development between the 5th and 9th week from flowering. Before this period the fruits grow vigorously, and so do leaves and shoots. The developing leaves compete with the fruits and the fruits compete with one another. The result is that many fruits drop.
Alar and CCC were applied to eliminate excessive fruit drop by growth retardation of the leaves and the shoots.

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Materials and methods

Growth regulators were applied to 4 years old trees of the pear varieties Beurré Hardy and Doyenné du Comice, and the apple varieties Cox's Orange Pippin and Golden Delicious, grown in 50-litre containers. The trees were placed in an unheated glasshouse where they flowered. The minimum temperature was 18° C.
Each of the trees had at least 50 spurs. The flower buds on the one-year shoots were not counted, nor were they used in the experiments. The top flowers of the clusters and the other flowers, which were not used, were removed before the treatments.
In the fruit set experiments each treatment included 120 clusters, spread over four trees. The number of blossoms was reduced to 3 per cluster before the treatments. The flowers were not covered, as in the glasshouse no insects were seen at any time. The experiments included treatments with and without pollination by hand.
For the experiments aimed at reducing June drop the fruits from pollinated flowers were used. The treatments were carried out on the 21st day after pollination by spraying the fruitlets. In addition to sprays, aqueous solutions with 14 mg of active substance per tree were injected into the trunk.
The effect of gibberellin A_3 and Alar on competitive fruit growth was studied with Beurré Hardy pears. Per treatment 100 clusters were used with 3 flowers and 100 with 5 flowers, distributed over 20 trees. The flowers were pollinated by hand with Doyenné du Comice pollen.
Aqueous solutions were used of the chemicals: 6-furfurylaminopurine (Kinetin, K) at 25 ppm, gibberellin A_3 (GA_3) at 25 ppm, a mixture of 28% gibberellin A_4 and 72% gibberellin A_7 (GA_{4+7}) at 25 ppm, N-dimethylaminosuccinamic acid (Alar) at 2500 ppm and (2-chloroethyl)trimethylammonium chloride (CCC) at 2500 ppm.
Fruit set was considered positive when swelling of the young fruitlets was observed on the 32nd day after flowering. The trees were taken out of doors on the 64th day from full flowering time.

Experimental results

Fruit set
The effects of the growth regulators on fruit set, recorded on the 32nd day after treatment, are presented in Table 1.
Hand pollination has a marked effect. The application of K has a positive influence on the fruit set both with and without pollination. The effect of K is stronger in pears than in apples. The effect of GA_3 on pears, already wellknown, is very clear here and the high fruit set without pollination is particularly striking. After a GA_{4+7} treatment the fruit set of Doyenné du Comice is very high, even higher without than with hand pollination.
Gibberellins stimulated seed abortion. After a GA_3 treatment, there was 26% seed abortion and after a treatment of GA_{4+7} 42% abortion in the harvested fruits of the pollinated flowers. In the other pollinated varieties no seed abortion was observed. A marked stimulating effect of gibberellins on the fruit set of Golden Delicious was found.
The retardants Alar and CCC did not increase fruit set. Alar reduced the fruit set of pollinated Doyenné du Comice flowers.

Table 1 Effects of growth regulators on fruit set of unpollinated (— p) and pollinated (+ p) blossoms as percentage of treated flowers. Treatments were carried out at full flowering time.

Variety		*Treatments*					
		control	*K*	*GA_3*	*GA_{4+7}*	*Alar*	*CCC*
Beurré Hardy	— p	4	11	53	—	0	0
	+ p	29	48	81	—	26	39
Doyenné du Comice	— p	0	8	64	87	1	3
	+ p	49	60	58	76	21	37
Cox's Orange Pippin	— p	6	21	—	30	2	0
	+ p	47	50	—	69	39	42
Golden Delicious	— p	0	7	15	23	1	0
	+ p	26	24	28	32	18	27

June drop

The results of the treatments are presented in Table 2. The data are expressed in percentage of fruit drop during the period from the treatment (21st day after full flowering) to the 64th day after flowering.

A very high percentage of the Doyenné du Comice fruits dropped. A kinetin treatment reduced fruit drop of pears, but not of apples. GA_3 had no effect on the abscission of Beurré Hardy fruits, but reduced the June drop in Doyenné du Comice. GA_3 stimulated the June drop of Cox's Orange Pippin and Golden Delicious. In pears, the effect of GA_{4+7} was the same as that of GA_3, but in apples GA_{4+7} had no effect. Both Alar and CCC strongly reduced the percentage of fruit drop, in pears as well as in apples. June drop was eliminated almost completely when Alar and CCC were injected into the trunk. GA_3, when applied together with Alar, did not neutralize the effect of this compound.

Table 2 Effects of growth regulators on fruit drop as percentage of treated fruitlets. The treatments were carried out at the 21st day after pollination by spraying the fruitlets or (between brackets) by injection in the trunk.

Variety	*Treatments*						
	control	*K*	*GA_3*	*GA_{4+7}*	*Alar*	*CCC*	*GA_3 + Alar*
Beurré Hardy	50	31	52	61	17	38	(26)
Doyenné du Comice	94	41	68	50	30	73	—
Cox's Orange Pippin	21	26	57	25	11 (9)	18 (3)	(13)
Golden Delicious	30	33	41	36	14 (1)	21 (5)	(16)

Fruit set to harvest

The total number of harvested fruits from 100 clusters is shown in Table 3.

If all the flowers form fruits, 300 and 500 fruits may be harvested from the 100 clusters. Although in the clusters with 3 flowers the percentage of fruit set is higher than in clusters with 5 flowers, the total number of set fruits is higher in the latter. From clusters with 5 flowers almost twice as many fruits were harvested as from

Table 3 Influence of GA_3 and Alar on the total number of set and harvested fruits of Beurré Hardy pears. Per treatment 100 clusters, each with 3 or 5 flowers, were used. GA_3 was applied at full flowering time; Alar three weeks later.

Treatments	*3 flowers per cluster*		*5 flowers per cluster*	
	fruit set	*harvest*	*fruit set*	*harvest*
untreated	78	41	110	77
GA_3	243	142	422	203
Alar	73	70	168	141
GA_3 + Alar	247	191	399	275

clusters with 3 flowers, which means that in both cases the percentage of flowers which gave a fruit was about 15%.

A treatment with GA_3 strongly increased fruit set. This high number of fruits could not be kept on the tree until the harvest, certainly not in the treatment of 5 flowers per cluster. Even so, the crop after GA_3 treatment was three times as high as that of the untreated trees. An application of Alar almost completely eliminated the drop

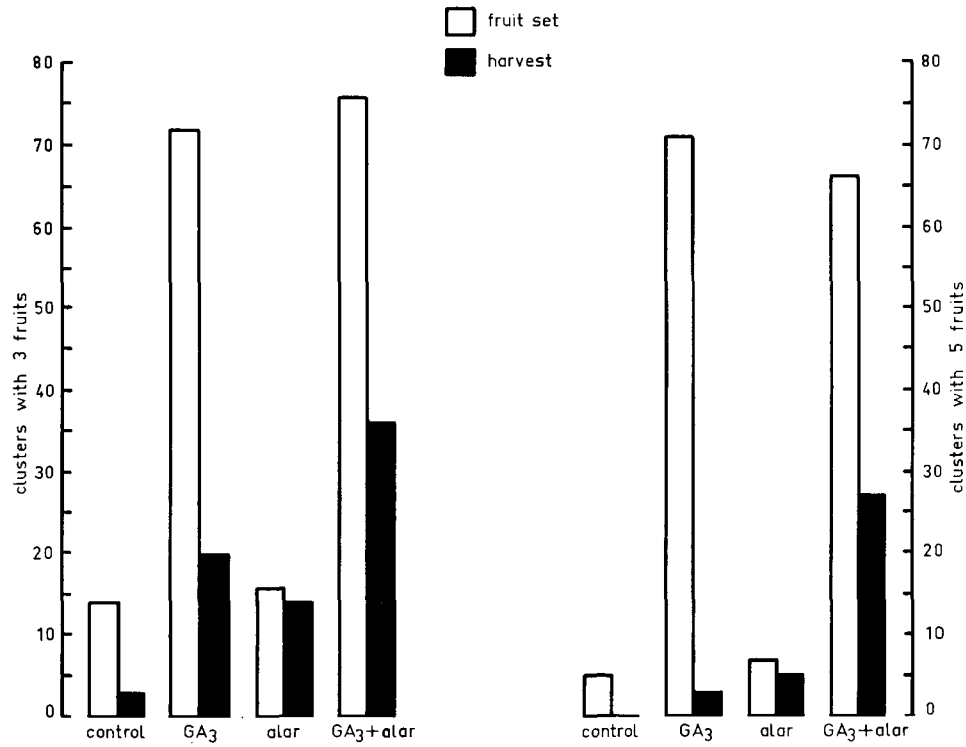

Fig. 1 Influence of GA_3 and Alar on the number of clusters pruned to 3 flowers (left) or 5 flowers (right), at the time of fruit set and at harvest.

of the fruits in the clusters with 3 flowers. Even in the clusters with 5 flowers fruit drop was strongly reduced.
In the combined treatment, both effects occurred simultaneously. GA_3 markedly increased fruit set and many fruits were retained by Alar until the final harvest.
The effect of GA_3 and Alar is even more clear when only those clusters are taken into account which kept 3 or 5 fruits from fruit set to harvest. These data are presented in Fig. 1.
Only 3 clusters have given a harvest of 3 fruits per cluster and not one cluster has given 5 fruits without any treatment. After a GA_3 treatment 20 clusters beared 3 fruits and only 3 clusters beared 5 fruits. After an Alar treatment, the number of clusters with 3 and 5 fruits was not markedly decreased. The strongest effect was obtained after the combined use of both types of regulators. At harvest time 36 clusters bore 3 fruits and 27 clusters 5 fruits. This is a very marked improvement of the crop in comparison with the control and GA_3 or Alar alone.

Discussion and conclusions

Pollination stimulated fruit set, but so did kinetin and the gibberellins. It seems that in the Doyenné du Comice pear (Table 1) pollination can be adverse for fruit set if combined with a gibberellin treatment. Alar did not increase, and sometimes even decreased, fruit set. That it nevertheless had a positive effect on yield was caused by the inhibition of June drop.
Most of the set fruits were lost in June. Many more fruits dropped from trees treated with gibberellin than from the untreated trees. Nevertheless, the former yielded more fruits than the latter. It is of further interest that in Beurré Hardy pears the 27 clusters with 5 fruits each have given a higher yield in the most succesful combination of GA_3 + Alar than the 36 clusters with 3 fruits each. The percentage of these clusters in the total crop was lower (49%) in the case of 5 fruits per cluster than in the case of 3 fruits (56%). This suggests that a stronger competition occurs when there are 5 fruits in a cluster than when there are only three.

Acknowledgments

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