INDUCTION OF PARTHENOCARPY IN APPLE AND PEAR WITH MIXTURES OF GROWTH REGULATORS

H. Jonkers
Department of Horticulture
Agricultural University
Wageningen,
The Netherlands
Publication 440

Abstract

In 5 experiments with the apple cv. 'Cox's Orange Pippin' and the pear cv. 'Doyenné du Comice' destyled and control flowers were sprayed with a mixture of a gibberellin, an auxin and a cytokinin resulting in parthenocarpic fruits. The most effective time for the application of the spray to the apple was at 40% of flowering. Often these fruits were smaller than control ones, however, and longer in shape. If parthenocarpic fruits have to compete with seeded ones, they are shed easily. Whether such a spray may be economical on apples and pears after spring frosts or with lack of pollination is a remaining problem.

Introduction

Since the paper of Kotob and Schwabe (1971) it was shown again by Schwabe (1973), Goldwin and Schwabe (1974, 1975) and Goldwin (1977) that during 8 successive years parthenocarpic fruits of the apple cv. 'Cox's Orange Pippin' could be obtained by sprays with mixtures of growth regulators containing a gibberellin, an auxin and a cytokinin. It depends on the cultivar whether such a mixture is necessary. In the USA a mixture of a gibberellin and a cytokinin, without auxin, was successful in inducing parthenocarpy in the cultivars 'Red Delicious' and 'Sturmer' (Williams and Letham, 1969). The apple cultivar 'Bramley's Seedling' sometimes will set fruit after a spring frost with GA_{4+7} alone (Modlibowska, 1975), the addition of a cytokinin, however, improves the result (Modlibowska and Wickenden, 1977). In the paper of Kotob and Schwabe (1971) it was concluded that a late spray viz. one week after full bloom would be the best; since then, however, Schwabe (1973) and Goldwin and Schwabe (1974) have concluded that sprays ought to be carried out at 50% of petal fall and that this moment seems to be very critical. Parthenocarpic and seeded fruits are in competition if both are on the same tree and seeded fruits generally win; this may be a serious handicap after sprays with mixtures of growth regulators (Goldwin and Schwabe, 1974; Goldwin, 1977). Occasionally one can obtain natural parthenocarpy of the apple cv. 'Cox's Orange Pippin' when caged before flowering time although this is unusual (Goldwin, 1977). The ratio between length and diameter of the fruit may increase after the application of GA_{4+7} + BA according to Westwood and Bjornstad (1968), or GA_3 in high concentrations (Goldwin and Schwabe, 1974). It should be noted that parthenocarpic fruits of 'Cox's Orange Pippin' were significantly smaller than seeded control fruits (Goldwin and Schwabe, 1974). Both authors also noticed that no reduction of the number of fruit buds was obtained in the year following the treatment.

The purpose of the present investigations is to study the concentration of the growth regulator mixture, the time of application and

the number of sprays on the apple 'Cox's Orange Pippin' and the pear 'Doyenné du Comice'. The mixture GA_{4+7} + NAA + BA or PBA was chosen.

Abbreviations

BA = 6-benzylaminopurine (SD 4901)
GA_{4+7} = commercial mixture of GA_4 and GA_7 sold by ICI (England)
NAA = α-naphtylacetic acid
PBA = (6-benzylamino)-9-(tetra hydro-2-pyranyl)-9H-purine (SD 8339)
Tween 20 = polyoxyethylenesorbitanmonolaurate

Materials, methods and results

Experiment 1

In 1973 twenty-three orchard trees of the apple 'Cox's Orange Pippin' on M. 2, age 5 years, were used. Similar branches were selected and thinned to 5 fruit buds. Trusses were bagged and the styles of the flowers were removed (called destyled) prior to spraying. Per treatment 50 trusses of 2 flowers each were treated. Sprays were carried out with a mixture of GA_{4+7} 600 ppm + NAA 40 ppm + BA 300 ppm. In one treatment PBA was used instead of BA. There were 3 moments of spraying viz. at 40% of flowering, at full bloom and one week after full bloom. Half of the treated flowers were sprayed again 3 weeks after flowering with GA_{4+7} 30 ppm to reduce drop. As controls 200 flowers were used, half of which were destyled, while the other half flowered freely in the open.

Parthenocarpic fruits were obtained after the application of a mixture of growth regulators on destyled flowers. Contrary to the observations of Kotob and Schwabe (1971) late applications were not better than applications during full bloom, probably because the weather was warm during flowering and abscission of unpollinated flowers took place soon after full bloom. This also happened in England and was confirmed by Schwabe (1973) in a later paper. Our most effective period of application occurred at 40% of flowering. In all treatments, except the one with PBA, the number of harvested fruits was lower than in the free pollinated control, while fruit quality and fruit weight were also negatively affected. The extra spray with GA_{4+7} 3 weeks after flowering reduced fruit drop, which is in accordance with the results of Wertheim (1971). Many fruits were cracked and russeted, however.

Experiment 2

In 1975 fifteen fresh trees of the apple 'Cox's Orange Pippin' on M. 2, age 7 years, were treated. The same lay-out was followed as in experiment 1. For the controls, which were either pollinated freely or destyled, 80 flowers were used, while all other treatments had 40 flowers. The mixtures of growth regulators containing GA_{4+7} 600 ppm + NAA 40 ppm + BA (or PBA) 300 ppm, were used at full strength, at a half or at a quarter of full strength. The sprays were carried out once, twice or 3 times. This makes 18 treatments, viz. 2 different mixtures x 3 strengths of the mixture x 3 numbers of application.

The number of fruitlets retained 3 weeks after the first spray was higher on treated than on control branches. The highest concentrations resulted in the biggest number of fruitlets, but the quality of the fruits with regard to size, shape and appearance was much better at the lowest concentration. The number of applications increased the number of

fruitlets retained. PBA gave more and bigger fruits than BA and less leaf damage. Fruit height increased if the concentration of the spray decreased; sprays with PBA gave more elongated fruits than sprays with BA.

Experiment 3

In 1976 thirteen fresh trees, 8 years old, of the apple 'Cox's Orange Pippin' on M. 2, were used. Before floweringtime 2 trees were caged for 4 weeks in a framework covered with fine muslin cloth. Ten days prior to full bloom a severe spring frost had damaged more than 60% of the fruit buds. Four treatments were given:
- one tree was caged and not sprayed
- one tree was caged and sprayed
- seven trees were sprayed but not caged
- four trees were untreated

The first spray applied contained: GA_{4+7} 300 ppm + NAA 20 ppm + BA 150 ppm and Tween 20 (0.05%) added as surfactant. The spray was carried out at full bloom. Three weeks later a second spray was given with GA_{4+7} 30 ppm.

In Table 1 the results are shown.

Table 1

Treatment	No. of fruits/100 trusses		
	5 w after spray	At harvest	Seeds/fruit
Control	194	74	6.4
Sprayed	178	75	6.8
Caged	14	3	0.7
Caged + sprayed	50	39	0.0

The effect of caging is clear. The tree which was caged and sprayed gave more fruit than caged alone, but it did not reach the level of the control. Also the sprayed trees were not better than the control, which showed a good set. Fruit bud formation as counted in the next spring, was not influenced by the spray.

Experiment 4

In 1975 thirty-two trees of the pear 'Doyenné du Comice' / Quince M.A virusfree were used. They were in their fifth year and growing in buckets of 25 l. Besides the control 4 treatments were given with mixtures of GA_{4+7}, NAA and BA (see Table 2). Tween 20 (0.05%) was added as surfactant. Trees were put in temperature-controlled greenhouses at constant temperatures of 9°, 13°, 17° and 21°C, 8 trees per greenhouse. Per tree 20 clusters of 2 flowers were treated, divided over 4 branches.

In Table 2 the percentages are given of fruits obtained out of 40 flowers.

Table 2

Growth regulator treatment			Temperature in the phytotron in °C				Average
			9	13	17	21	
Control			5	0	0	0	1
GA_{4+7} + NAA + BA/PBA in ppm							
600	40	300	30	28	18	5	20
300	20	150	53	48	50	20	43
600	40	300	40	8	0	3	13
300	20	150	20	15	8	8	13
		Average	37	25	19	9	

At lower temperatures fruit set was better (see bottom line). Of the mixtures GA_{4+7} 300 ppm + NAA 20 ppm + BA 150 ppm was the most effective. Leaf damage was very pronounced at the mixture containing BA 300 ppm. Empty seeds were found in fruits at 9°C, somewhat less at 13°C and none at 17°C and 21°C. Fruits did not ripen at 9°C, somewhat better at 13°C, still better at 17°C and best at 21°C. Fruit bud formation during the next year was weak after 9°C, much better after 13°C and, surprisingly, completely absent after 17° and 21°C.

Experiment 5

In 1976 fourteen orchard trees of the pear 'Doyenné du Comice' / Quince M.A, age 7 years, were used. As described in experiment 3 some trees were caged. The following treatments were applied: control, caged, destyled, sprayed, caged + sprayed and destyled + sprayed. One spray was applied, containing: GA_{4+7} 25 ppm + NAA 20 ppm + BA 150 ppm, while Tween 20 (0.05%) was added as a surfactant.

The control trees had the most fruits, both before the June drop and at harvest time. The spray had no significant effect on fruit set. After destyling or caging a number of fruits without seeds was obtained. This means that the cultivar has a tendency to form parthenocarpic fruits if seeded fruits are absent. The fruits obtained after spraying had a tendency to become more elongated than fruits of the control. Fruit bud formation in the following year was not influenced by the spray, although most trees showed a tendency for biennial bearing.

Discussion

In the apple cv. 'Cox's Orange Pippin' (experiments 1-3) and the pear cv. 'Doyenné du Comice' (experiment 4) we could obtain parthenocarpic fruits but only if flowers were destyled and not on flowers open pollinated; obviously in the competition with seeded fruits the parthenocarpic fruits were worsted. The most effective time of application for the apple was 40% of flowering (experiment 1) which confirms the results by Schwabe (1973) and Goldwin and Schwabe (1974). The fruit weight often decreased (experiments 1, 2 and 3) which is a real drawback for the application of these mixtures: choosing the best concentration (experiment 2) is of the utmost importance. In this case this was GA_{4+7} 150 ppm + NAA 10 ppm + BA (or PBA) 75 ppm. More applications give better

results than one application (experiment 2). In the apple PBA gave more elongated fruits than BA.

With the pear cv. 'Doyenné du Comice' the mixture of GA_{4+7} 300 ppm + NAA 20 ppm + BA 150 ppm was most effective in the phytotron. It is remarkable that trees which had been at 17° or 21°C (constantly) did not form any fruit buds at all either on sprayed or control trees (experiment 4). On pear trees in the open the mixture had no significant effect. This may be due to lowering the concentration of GA_{4+7} to 25 ppm in order not to reduce the number of fruit buds in the next year.

Generally sprays with a mixture of a gibberellin, an auxin and a cytokinin were not very successful on trees in the open, neither with apple nor with pear. In England it is expected that these sprays will be most effective on trees with frozen flowers or trees with lack of pollination (Goldwin and Schwabe, 1974). This has not yet been shown in the Netherlands. Another doubt can be expressed towards the use of the cytokinins BA or PBA; as they are synthetic promotors of cell division, they probably will never be cleared for use on edible crops (Mr. van der Harst, Shell, The Netherlands, private communication). In England BA or PBA have been replaced by diphenylurea which occurs in nature and may have a better chance (Goldwin, 1977). Throughout our experiments we applied GA_{4+7} which is 7 times more expensive than GA_3. According to Modlibowska and Wickenden (1977) GA_{4+7} can be replaced by GA_3. Still the spray is so expensive that no more than one application will be feasible in practice. It remains to be shown that there are any possibilities for application in commercial fruit production.

Acknowledgement

It is a pleasure to thank Mr. O. Borsboom for the care he gave to the experiments and to the members of the Staff of the Department of Horticulture for their critical remarks on the manuscript.

Literature

Goldwin, G.K., 1977. Grower 87(4): 210-211.
Goldwin, G.K. and Schwabe, W.W., 1974. Proc. 12th British Weed Control Conference: 131-136.
Goldwin, G.K. and Schwabe, W.W., 1975. J. Hort. Sci. 50: 175-178.
Kotob, M.A. and Schwabe, W.W., 1971. J. Hort. Sci. 46: 89-93.
Modlibowska, I., 1975. J. Hort. Sci. 50(1): 21-22.
Modlibowska, I. and Wickenden, M.F., 1977. Grower 87(14): 805-806.
Schwabe, W.W., 1973. Acta Hort. 34(1): 311-316.
Wertheim, S.J., 1971. Comm. Agric. Univ. Wageningen, The Netherlands 71(17): 73 pp.
Westwood, M.N. and Bjornstad, H.O., 1968. HortScience 3(1): 19-20.
Williams, M.W. and Letham, D.S., 1969. HortScience 4(3): 215-216.