Application of gibberellin and cytokinin in crown formation of apple trees

H. PLICH and L. S. JANKIEWICZ

Research Institute of Pomology, Skierniewice, Poland

(Received: October 30, 1972)

Abstract

Lanolin paste containing a mixture of gibberellin and cytokinin was smeared in February and March on the 8 buds chosen to form scaffold branches. The treated buds developed 5 - 10 days earlier than those smeared with lanolin alone. They formed shoots longer than those of the control trees. The applied growth regulators had no influence upon the crotch angles.

INTRODUCTION

A trend has occurred in recent years to transplant one-year-old instead of two-year-old apple trees to the orchard. However, when the spring is dry, as often is the case in Poland, or when the trees are weakened during transplanting it is difficult to obtain suitable shoots for crown formation. Under such conditions often only the 2 or 3 uppermost lateral buds grow into long shoots. Such shoots are in most cases not useful as scaffold branches due to their narrow crotches. Recently Williams and Billingsley (1970) have used lanolin paste containing a mixture of gibberellin and cytokinin to promote the growth of buds chosen to form future scaffold branches. In our work we have tried to apply this method under Polish conditions and to modify it using different concentrations of growth regulators and by replacing the expensive gibberellin A_{4+7} with A_3 , a less expensive one.

MATERIAL AND METHODS

Experiments were conducted using McIntosh and Wealthy trees.

These two cultivars differ markedly in their character of growth. Wealthy trees showing a much more pronounced dominance of the

uppermost branches over those situated lower on the axis. The trees of each cultivar were divided into 2 groups which were grown under different conditions:

1. One group was left in the nursery without transplanting, so that their growth was vigorous.

2. The trees of the second group were transplanted into 10 liter pails in the autumn. During the winter they were kept in a cold greenhouse with their roots protected. During the spring they were moved out of doors and watered regularly. Their growth was markedly less than the growth of the trees left in the nursery.

Eight consecutive buds at the height of the future tree crown i.e. 60 - 80 cm above the soil level, were treated with hydrated lanolin containing growth regulators. The control trees were of 2 kinds: those treated with hydrated lanolin alone and "intact controls" with the buds left untreated. The lanolin paste was smeared on individual buds with a brush.

The paste was applied to the trees growing in the pails 2 months before bud bursting (on February 15th) and to the trees growing in the nursery 1 month before bud bursting (on March 18th). When the buds of the lanolin treated control trees had grown into shoots 3 - 5 cm long the treated trees were cut back leaving 2 intact buds above the treated zone. The "intact control" trees were cut at a similar height.

The length of the shoots was measured twice: in the middle of May at the time when the trees were cut back, and in late summer or early autumn after growth had ceased. The measurement of the crotch angles was done only once, at the end of the vegetative season.

The experiment was set up in 8 - 10 randomized blocks with each tree representing a plot. The results were evaluated statistically using the method of analysis of variance with Duncan's test for significance.

RESULTS

Shoot growth. A comparison of the control trees treated with lanolin with those untreated showed that pure hydrated lanolin has an adverse effect upon shoot growth during the early stages of development. In the case of McIntosh trees growing in pails the two groups of control trees showed significant differences in shoot length throughout the whole vegetative season (Table 1).

Buds treated with a mixture of benzyladenine (BA) and gibberellin (GA₃) began their spring development earlier than those of control trees by 10 days for the nursery trees and by 3 - 5 days for the trees growing in pails. These early developing shoots were injured by spring frosts in the case of the trees growing in the nursery. In the middle of May the

Table 1

The influence of growth regulators on the sum of growth increments of 8 treated buds in cm/tree

(Separate statistical analysis for each column)

Cultivar	Trees in the nursery*				Trees in pails**			
	McIntosh		Wealthy		McIntosh		Wealthy	
Date of measurements	May 17th	August 11th	May 14th	August 11th	May 18th	September 30th	May 18th	September 30th
Control untreated trees	64.3 _{bc} *	468.8 _a	19.8 _{bc} *	304.2 _{ab}	11.9 _a **	227.4 _c	8.6 _a **	83.3 _{ab}
Controls treated with lanolin alone	42.6 _a	431.9 _a	12.2 _{ab}	293.8 _a	8.1 _a	99.0 _a	8.6 _a	31.3 _a
BA 0.02%	46.7 _{ab}	479.6 _a	10.8 _a	299.6 _a	11.9 _a	164.0 _{abc}	9.0 _a	59.8 _{ab}
BA 0.1%	43.4 _{ab}	438.4 _a	13.9 _{ab}	376.8 _{bc}	22.1 _a	175.5 _{abc}	12.9 _{ab}	94.0 _{ab}
GA ₃ 0.1%	59.8 _{abc}	529.9 _a	14.1 _{ab}	335.8 _{ab}	13.7 _a	105.7 _{ab}	8.1 _a	47.8 _{ab}
BA 0.02% GA ₃ 0.1%	58.2 _{abc}	519.8 _a	16.2 _{ab}	325.4 _{ab}	17.1 _a	158.6 _{abc}	15.2 _b	113.2 _b
BA 0.1% GA ₃ 0.1%	62.9 _{bc}	506.7 _a	23.8 _c	339.0 _{abc}	30.7 _a	181.1 _{bc}	17.9 _b	111.8 _b
BA 0.5% GA ₃ 0.5%	69.4 _c	487.1 _a	53.4 _d	445.5 _c	—	—	—	—

* Averages for 10 replicates.

** Averages for 8 replicates.

The values marked with the same letter do not differ significantly.

shoots of the trees smeared with the mixture of both growth regulators were, in most cases, significantly longer than the shoots of the control trees treated with lanolin alone. In Wealthy trees the buds treated with the highest concentration of BA + GA₃ produced longer shoots than did the buds of the intact control trees. At the end of the vegetative season the differences between the control trees treated with lanolin and those treated with the highest concentration of BA + GA₃ were in most cases significant. The difference between shoot lengths of BA + GA₃ treated trees and the untreated control trees was significant, however, only in the case of Wealthy trees growing in the nursery.

In contrast to that which was found by Williams and Billingsley (1970) the trees treated with BA + GA₃ showed no marked inhibition of shoot growth below the treated zone.

The crotch angles of the treated trees of both cultivars were rather large (over 43°). Even the leader was inclined at an angle of 40–55° from the vertical. In contrast to the findings of Williams and Billingsley (1970) there were no differences in crotch angle width between the treated and control trees in this experiment (Tables 2 and 3).

Table 2
The influence of growth regulators on crotch angle width (in degrees) in apple trees growing in the nursery.
Averages of 10 replicates

The branches			Untreated shoots				Shoots treated with growth regulators, or respective shoots in control trees							
Treatment		Angle	the leader		branch 1		branch 2		branch 3		branch 4		branch 5	
1*	2**		1	2	1	2	1	2	1	2	1	2	1	2
Wealthy														
Control untreated trees			46.6	16.3	48.0	23.8	47.6	37.1	51.3	46.7	52.5	44.9	51.4	47.6
Control trees treated with lanolin only			51.6	28.3	49.5	34.1	50.4	38.0	45.4	41.9	52.4	47.6	56.3	52.3
BA 0.1% + GA ₃ 0.1%			51.6	24.8	49.5	33.7	47.2	38.7	54.4	43.0	55.8	48.0	60.0	56.6
BA 0.5% + GA ₃ 0.5%			54.0	28.4	50.7	38.8	45.3	43.8	51.3	47.6	54.6	51.9	60.1	58.6
The trees cut back in early spring**			12.2	8.8	15.6	15.4	24.5	23.1	40.5	38.7	47.5	49.4	53.4	55.5
McIntosh														
Control trees with lanolin only			52.4	40.7	52.7	43.3	51.4	47.7	55.1	59.1	60.8	61.5	62.5	65.8
BA 0.1% + GA ₃ 0.1%			54.9	39.6	55.6	45.4	52.2	47.8	54.6	54.0	57.7	58.3	57.7	61.5
BA 0.5% + GA ₃ 0.5%			46.3	34.4	43.5	39.7	43.3	41.7	46.0	48.2	51.7	52.1	54.0	57.6
The trees cut back in early spring**			32.0	23.1	30.5	29.7	30.0	28.5	36.4	40.5	44.5	46.9	47.0	53.0

* The angle 1. was measured 0.5 - 1 cm from the insertion of the branch, the angle 2 was measured in the same branches 5 cm from the point of insertion.

** The trees not included into the experiment but growing side by side with experiment trees.

Table 3
The influence of growth regulators on crotch angle width (in degrees) in apple trees growing in pails.
Averages of 8 replicates

The branches		Untreated shoots				Shoots treated with growth regulators or respective shoots in control trees									
Treatments	Angle	the leander		branch 1		branch 2		branch 3		branch 4		branch 5			
		1*	2*	1	2	1	2	1	2	1	2	1	2		
		Wealthy													
Control untreated trees		32.8	11.8	34.2	21.8	30.5	23.1	40.6	45.0	36.0	48.5	39.0	30.0		
Control trees treated with lanolin only		33.4	12.6	27.6	18.2	30.6	16.8	37.2	30.0	45.5	41.0	44.3	31.3		
BA 0.1% + GA ₃ 0.1%		32.1	13.4	33.5	16.6	40.2	24.8	39.7	35.2	45.6	39.3	51.8	41.8		
McIntosh															
Control untreated trees		53.2	35.2	54.3	35.3	54.7	43.3	59.6	56.8	59.5	57.2	63.7	60.3		
Control trees treated with lanolin only		48.6	32.6	49.2	38.0	45.2	40.4	56.2	55.3	52.0	45.5	56.2	51.5		
BA 0.1% + GA ₃ 0.1%		45.4	28.8	44.3	37.0	51.3	42.8	52.1	48.6	54.0	52.6	55.0	54.6		

* The angle 1. was measured 0.5 - 1 cm from the insertion of the branch, the angle 2 was measured in the same branches 5 cm from the point of insertion.

Large crotches and an inclined leader are characteristic traits of trees which were cut back in early or middle May as it was done in this experiment (Jankiewicz 1967). The uppermost crotch angles of the trees which were cut back in March were narrow (Table 2).

DISCUSSION

Treatment of buds with a mixture of cytokinin and gibberellin caused their earlier development and promoted shoot growth. This confirms the results of Williams and Billingsley (1970). In a cold climate such as that of Poland the early development of buds may often lead to frost damage of the young leaves. The stimulation of growth due to treatment with BA + GA₃ in our experiments was not as spectacular as that reported by Williams and Billingsley (1970) in spite of the higher concentration of growth regulators which were used. We also did not observe inhibition of shoot growth below the treated zone. This may be at least partly explained by the fact that we used GA₃ instead of GA₄₊₇. The gibberellin GA₃ is less active or at least less easily transported in apple trees than GA₄ or GA₄₊₇ (Fulford et al. 1968; Jankiewicz et al. 1973).

The highest concentrations of growth regulators used in our experiments stimulated the growth most. This indicates that the optimal level of growth regulator activity may not have been reached and that a still higher concentration should be used in future experiments. As in the experiments of Williams and Billingsley cytokinin and gibberellin used separately were either inactive or were only weakly active in our experiments.

The inhibition of bud growth using lanolin alone indicates a need of a further search for a better medium to dissolve the growth regulators.

In contrast with the results of Williams and Billingsley we were unable to find any effect of a mixture of BA + GA₃ upon the crotch angle width. There was only a very marked effect of late decapitation as compared with early decapitation, which is in accordance with earlier results of Verner (1955), Jankiewicz (1956, 1964, 1967) and of Firichenkov (1971).

It is hoped that the method of Williams and Billingsley may find practical application in Poland after better adapting it to the conditions of a cold climate.

From a theoretical point of view the synergism between cytokinin and gibberellin in apple shoot growth promotion is very interesting. The work of Plich and Jankiewicz (in press) indicates that a shoot which has already emerged from the bud is sensitive only to cytokinin

treatment and insensitive to GA_3 . Therefore it may be supposed that gibberellin applied acts during the stage before bud opening. Later on it does not act since it is probably produced in sufficient quantity in the tree. It is known that gibberellin lowers the temperature range in which the spring growth can begin (Vegis 1964). Possibly this might be the role of GA in our experiment, however, it could act only in the presence of cytokinin. The shoots which due to $GA_3 + BA$ developed earlier had the opportunity to gain the dominance over the other shoots (compare the results of Barnola 1970). Being dominating such shoots were able to monopolize a large part of the hormones and nutrients transported from the roots and the stem, and to inhibit the shoots situated lower on the axis (Williams and Billingsley 1970) by a positive feedback mechanism (Jankiewicz 1972).

This paper was partly supported by U.S. Department of Agriculture, Agricultural Research Service, Grant No. 199 and 265, under Public Law 480.

REFERENCES

- Barnola P., 1970, *Ann. Sci. Nat. Botanique* 12 ser., 11: 129 - 152.
 Firichenkov S. T., 1971, *Niekotoryie voprosy formirovaniya krony osnovnykh sortov jabloni v niechernozemnoy zonie RSFSR*, Autoref. Ph. D. Thesis, Moskva.
 Fulford R. M., Quinlan J. D., Lacey H. J., Barlow H. W. B., 1968, [In:] Wightman F. and Setterfield G. (eds) *Biochemistry and Physiology of Plant Growth Substances*, Runge Press. Ottawa, pp. 1169 - 1185.
 Jankiewicz L. S., 1956, *Bull. Acad. Polon. Cl. II*, 4: 173 - 178.
 Jankiewicz L. S., 1964, *Acta Agrobot.* 15: 121 - 150.
 Jankiewicz L. S., 1967, *Prace Inst. Sad. (Warszawa)* 11: 35 - 42.
 Jankiewicz L. S., 1972, *Biol. Plant (Praha)*, 14: 52 - 61.
 Jankiewicz L. S., Plich H., Borkowska B., Moraszczyk A., 1973, [In:] Luckwill L. C. and Williams M. W. (eds), *Growth regulators in fruit production*.
 Plich H., Jankiewicz L. S., (in press), *Biol. Plant. (Praha)*.
 Verner L., 1955, *Univ. Idaho Agr. Exp. Sta. Res. Bul.* 28: 1 - 28.
 Vegis A., 1964, *Ann. Rev. Plant Physiol.* 15: 185 - 224.
 Williams M. W., Billingsley H. D., 1970, *J. Amer. Soc. Hort. Sci.* 95: 649 - 651.

Zastosowanie giberelin i cytokinin przy formowaniu koron jabłoni

Streszczenie

Doświadczenie założono na jednorocznych drzewkach odmiany 'McIntosh' i 'Wealthy'. Część drzewek każdej odmiany pozostawiono w szkółce (silny wzrost), część zaś przesadzono do wiader (słaby wzrost). Regulatory wzrostu w paście lano-linowej nakładano na pąki za pomocą szczoteczki 1-2 miesiące przed rozpoczęciem

wzrostu. Mieszanina gibereliny GA_3 i benzyloadeniny w stężeniach 0,1% i 0,1% lub 0,5% i 0,5% powodowała wcześniejsze wybicie pąków o 3-10 dni. Pędy, które z nich wyrosły były silniejsze niż pędy drzewek kontrolnych, ale nie posiadały większych kątów rozwidleń. Przypuszcza się, że metoda ta znajdzie zastosowanie w praktyce po dalszym jej ulepszeniu.