Kasetsart J. ( Nat. Sci. ) Vol. 24 : 218 - 223 ( 1990 )

# The Effects of Paclobutrazol, Calcium and Hydrogen Cyanamide on Growth Cessation and Bud Burst of Apple Grown Under Warm Glasshouse Conditions

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## ABSTRACT

Shoot growth of the Fuji apple cultivar was retarded by spraying with paclobutrazol at 500 ppm, four times during the growing season. Significant differences in the number of flower buds between the treated and the untreated trees were found. Carbohydrate and nitrogen levels in the treated trees was higher than in the untreated ones.

Both calcium and hydrogen cyanamide enhanced bud break but hydrogen cyanamide was more effective. Addition of " Merit " ( 7-5-3 ( NPK ) formula fertilizer ) to these chemicals increased induction of bud break under simulated tropical/sub-tropical conditions. Results varied with application time and these results are not fully understood and require further investigation.

## INTRODUCTION

Nowadays, it is known that many kinds of deciduous temperate zone fruits can be produced in the tropics and subtropics. However, when these deciduous fruit trees are grown under warm conditions where chilling is insufficient, their growth and yield are reduced. Trees invariably have unbranched long shoots which continue to grow all the year. Poor bud break and foliage development and sporadic bloom with abnormal flowers are commonly found. Thus, to be successful in growing deciduous fruit trees in these areas, the following processes are considered necessary : 1 ) Cessation of shoot growth, and 2 ) Bud break induction. These processes may be achieved by many means. Some chemicals are promising and practical for achieving bud break and cessation of growth. Control of growth of fruit trees can be achieved with growth retardants as reported in various experiments ( Lee and Looney, 1977 ; Quinlan, 1981 ; Stinchcombe *et al.*, 1984 ; Tromp, 1987 ; Wang and Faust, 1986 ). Chemicals now used commercially in the tropics and subtropics for budbreak induction are mineral oils, potassium nitrate, thiourea, promalin and cyanamide. Among these chemicals, cyanamide is one of the most effective rest-breaking agents ( Erez, 1987 ; George *et al.*, 1988 ; Kuroi *et al.*, 1963 ; Mayles *et al.*, 1987 ; Shulman *et al.*, 1983 ). Combinations using growth retardants and bud breaking agents may be more useful in improving deciduous fruit tree production in the tropics and subtropics, where both growth cessation and bud break are common problems. Our study investigates such combinations of growth retardants and bud break inducing chemicals for apple grown under simulate tropical/sub-tropical conditions in a glasshouse in Japan.

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## MATERIALS AND METHODS

In this study, the experiments were divided in two pats. Experiment 1 relates to the cessation of shoot growth while experiments 2 and 3 relate to bud break induction. The study was conducted in Japan, on potted glasshouse grown apple trees. To avoid cold and simulate tropical/sub-tropical growing conditions. Pot's size in this study was ten inches in diameter. Potting mixture was composed with the mixture of wood bark, sand and soil from the orchard in Tohoku University. Trees were sufficient watering during experiment and 20-10-20 fertilizer at five g per tree were applied to these trees before utilized in this experiment.

Potted-one-year-old Fuji apple trees on M26 rootstock in the number of 120 trees were taken from the experimental field in the Faculty of Agriculture, Tohoku University, and treated as follows : Before using them in the experiments 1 and 2. Firstly, old shoots were completely removed at the end of February, 1987 to stimulate direct emergence of new shoots from the trunk in the comming April. On May 13, when these new shoots reached a length of about 10 cm, three of them of similar length were kept while other shoots were pinched back. Half the number of these trees were sprayed with 500 ppm paclobutrazol ( triazole derivative growth retardant ) four times on : June 10, June 17, July 7 and July 23. On September 18, all trees were transfered to a heated glasshouse ( 15-25°C ) and utilized in experiment 1 and 2 below.

### I. Cessation of shoot growth

#### Experiment 1

Shoot length of both paclobutrazol treated and untreated trees was measured from thirty trees ( ninety shoots ) every month from June to November. Number of flower buds were counted from forty-five trees at the end of February, 1988, at the pink bud stage. At the beginning of March, trees were dug from pots, divided into four parts viz : new shoots, bark and wood, leaf and new root and prepared for analysis of carbohydrate and nitrogen by the method of Nelson ( 1944 ) modified by Somogyi ( 1945, 1952 ) and Kjeldahl ( 1883 ) modified by Cope ( 1916 ) respectively.

### II. Bud break induction

#### Experiment 2

On November 30, 1987, Fuji apple trees previously treated and untreated with paclobutrazol, were painted with 20% calcium cyanamide ( $CaCN_2$ ), either combined or uncombined with 50% " Merit " a 7-5-3 ( NPK ) foliar fertilizer. Each treatment consisted of single tree replicated eight times. Six weeks after the treatment, number of burst buds and buds that elongated to become new shoots were recorded.

#### Experiment 3

Between November 10, 1988 and January 12, 1989, two-year-old Tsugaru apple trees on *Malus prunifolia* rootstocks grown and maintained in heated glass house ( 15-25°C ) were painted on four occasions, three weeks apart with either 2.5% hydrogen cyanamide ( $H_2CN_2$ ) or 20% calcium cynamide ( $CaCN_2$ ) with and without " Merit ". Treatments were replicated four times with single tree plots. Trees were at dormant stage with about six to ten one-year-old shoots attached. These shoots had been cut back to the length about 15 - 20 cm which had about 7 - 10 buds remained. Fourteen weeks after treatment, number of the burst buds and new shoots that elongated from these buds were recorded.

## RESULTS AND DISCUSSION

#### Experiment 1

Paclobutrazol retarded vegetative growth in Fuji apple trees ( Figure 1 ) in the same way as shown by other studies ( Quinlan, 1981 ; Stinchcombe *et al.*, 1984 ; Tromp, 1987 ; Wang and Faust, 1986 ). Its principal mode of action is the inhibition of gibberellin biosynthesis by inhibiting

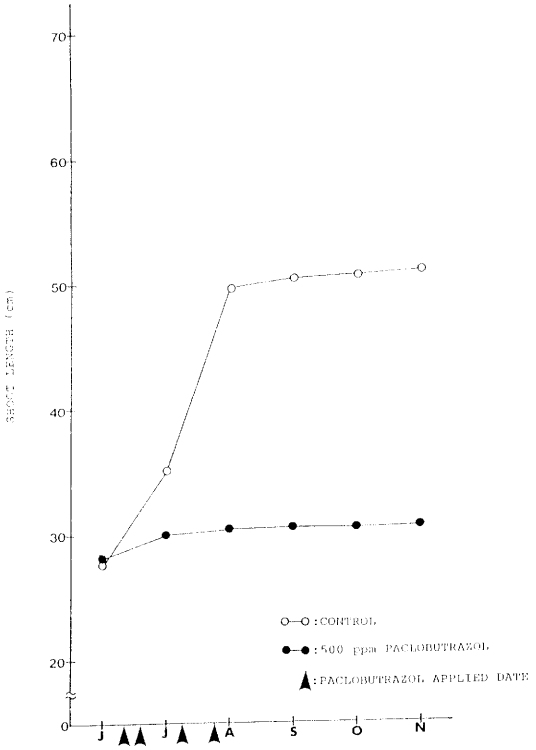


Figure 1. Effect of paclobutrazol on vegetative growth of cv Fuji apple trees. ( Experiment 1 )

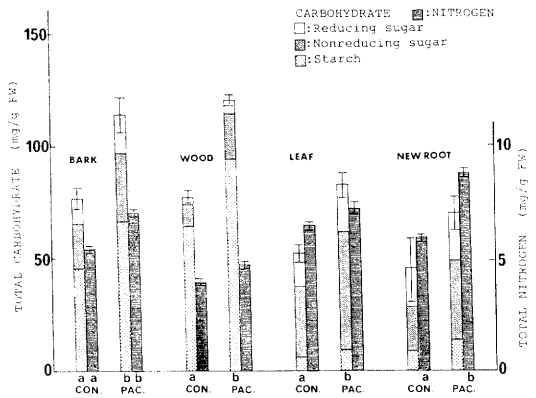


Figure 2. Effect of paclobutrazol on nutrient content of cv Fuji apple trees. ( Experiment 1 )

the oxidation of kaurene to kaurenoic acid. In addition, even trees utilized in this experiment were not at the age of bearing fruit, many flower buds were found obviously in trees that received paclobutrazol treatment ( Table 1 ). This is agrees with the studies reported by Stinchcombe *et al.* ( 1984 ) and Tromp ( 1987 ).

Carbohydrate content in the various sampled parts of paclobutrazol treated trees was markedly higher than in the untreated trees. It is suggested that paclobutrazol reduced vegetative growth so the carbohydrate and nitrogen reserves in paclobutrazol treated trees were higher than untreated ones since they were not consumed in the growth processes and this should be available for flower induction.

## Experiment 2

Kuroi *et al.* ( 1963 ) were the first to find that calcium cyanamide applied as an aqueous suspension after winter pruning terminated rest in grapevine. This was later confirmed by others ( Kaewpaluek, 1986 ; Yang *et al.*, 1982 ). In our experiment, calcium cyanamide was also found to increase the number of burst buds in Fuji apple trees ( Table 2 ). Calcium cyanamide failed to induce bud break in trees previously treated with paclobutrazol but when combined with " Merit ", it increased bud burst of these trees. " Merit " is a fertilizer containing nitrogen, phosphorous and potassium which are essential for growth processes. Thus, addition of " Merit " may enhance bud break by increasing growth of the bud. Most burst buds on paclobutrazol treated trees did not develop into new shoots. This effect is attributed to the residual effect of paclobutrazol which may last for many months.

## Experiment 3

In Tsugaru apple trees, hydrogen cyanamide markedly increased bud break for every application time while calcium cyanamide was much less effective ( Table 3 ). Shulman *et al.* ( 1986 ), showed that a greater effect was obtained with

**Table 1 Effect of paclobutrazol on flower bud induction in cv Fuji apple trees. ( Experiment 1 )**

| Treatment | Average number of bud break/tree | | |
|---|---|---|---|
| | Apical bud | Lateral bud | Total |
| Control | 0.20 | 0.02 | 0.22 az |
| 4 × 500 ppm Paclobutrazol Applications | 0.53 | 0.71 | 1.24 b |

z : Mean separation within the column by t-test at 1% level

**Table 2 Effect of Calcium cyanamide ( $CaCN_2$ ) with foliar fertilizer " Merit " on bud break induction in cv Fuji apple trees. ( Experiment 2 )**

| Treatment | Bud break ( % ) | | New shootx ( % ) | |
|---|---|---|---|---|
| | Untreated | Paclobutrazol | Untreated | Paclobutrazol |
| Control | 0 ay | 0 a | 0 a | 0 |
| 20% $CaCN_2$ | 19.3 b | 0.7 a | 0.4 a | 0 |
| 20% $CaCN_2$ + 50% Merit | 24 b | 4.5 b | 3.2 b | 0 |

x : Buds that elongated to 1.5 cm or more

y : Mean separation within the column by Duncan's multiple range test at 5% level

**Table 3 Effects of hydrogen cyanamide and calcium cyanamide singly and in combination with " Merit " foliar fertilizer on bud break induction and new shoot production on cv Tsugaru apple trees. ( Experiment 3 )**

| Treatment | 10 Nov. 88 | | 1 Dec. 88 | | 22 Dec. 88 | | 12 Jan. 89 | | Average | |
|---|---|---|---|---|---|---|---|---|---|---|
| | BB | NS | BB | NS | BB | NS | BB | NS | BB | NS |
| Control | 1.4 | 0 | 1.4 | 0. | 1.4 | 0 | 1.4 | 0 | 1.4 cz | 0 c |
| 2.5% $H_2CN_2$ | 18.9 | 9.2 | 32.3 | 6.9 | 23.9 | 6.6 | 26.6 | 8.7 | 25.4 b | 7.9 a |
| 20% $CaCN_2$ | 3.3 | 0 | 8.8 | 0 | 13.4 | 1.1 | 14.6 | 6.7 | 10 bc | 2 bc |
| 2.5% $H_2CN_2$ + 50% Merit | 38.8 | 6.8 | 53.6 | 8.2 | 19.3 | 0.6 | 54.8 | 10.8 | 41.6 a | 6.6 ab |
| 20% $CaCN_2$ + 50% Merit | 19.1 | 1.7 | 7.4 | 0 | 13.4 | 0.9 | 16.2 | 3.7 | 14 bc | 1.6 bc |

BB : Percentage of bud break

NS : Percentage of new shoot

Z : Mean separation within the column by Duncan's multiple range test at 5% level

hydrogen cyanamide than calcium cyanamide as a spray for inducing bud break in grapevines. They suggested that, free acid hydrogen cyanamide, which is assumed to be the active form of the chemical, is only partially liberated from a mixture of calcium cyanamide. Moreover, phosphate added to stabilize hydrogen cyanamide may have some effect in assiting bud break. With both cyanamides, " Merit " enhanced bud break, in a similar manner to experiment 2.

Application of these chemicals at different times produced different results. Applications on November 10 generally produced less bud break than later applications although there were some inconsistency viz the hydrogen cyanamide + " Merit " treatment on December 22 and the calcium cyanamide + " Merit " treatment on November 10. The reason why treatments applied on November 10 were less effective than the later applications is not clearly understood and requires further investigation. However, we could speculate that if leaves were present these could overide the effects of cyanamide. Edwards ( 1985 ), suggested that old leaves may be the source of abscisic acid which inhibits bud burst. Thus, by artificial defoliation may remove the source of abscisic acid which allow bud burst. Our study may be followed this suggestion since when the treatments applied on November 10, there were some old leaves still attached on the trees while the three later treatments were applied, almost of these leaves were already dropped. Percentage of new shoots in every treatment at every application time was still too low. Almost of these shoots were rosetted which is typified by the short internodes and the formation of a resting terminal buds. Erez and Lerner ( 1990 ), reported that, in Israel, rest breaking chemicals can improve bud break of peaches. However, the growth obtained is forming a rosette. They suggested that these caused by the residual dormant state, the short days and the low temperature in winter. In our study, effects of low temperature may be inattentive since the experiment was done in the heated glass house. However, the effects of day-length may played important role in this case since this experiment was done in Japan which the day length in winter is quite short.

Chemical utilized seem to have potential in improving apple tree under warm condition. Concentration of chemicals and time of application seem to be important for achieving best results. Other factors are also consider to be important and more investigations are required for more understanding which may leads to the successful of growing apple trees in Thailand and the other warm countries.

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