

Original Research Article

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Effect of Different Combinations of CPPU, GA₄₊₇ and 6-BA on Fruit Growth Rate on Developing Apple (*Malus domestica* Borkh) cv. 'Pinova'

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ABSTRACT

Keywords

Growth, Apple, CPPU, Promalin, Surface area

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The present study was conducted to determine the response of the plant growth regulators like CPPU, GA₄₊₇ and 6 BA to the growth of apple fruit in cultivated apple (*Malus domestica* Borkh) cv. 'Pinova' in Hannover, Germany. The study shows that the growth of apple fruit was significantly influenced by the CPPU, Promalin (GA₄₊₇ and 6 BA). Among the different treatments, the highest fruit growth and surface area were recorded with C2P2. It is also recorded the maximum value for the different growth parameters viz., fruit length, fruit diameter and fruit weight. The treatment with 20 mg l⁻¹ was also having a visible precedence in different aspects for instance fruit circumference, fruit weight, fruit volume in pinova etc.

Introduction

In the commercial production of apple various fruit growth regulators (PGR) are used. These PGR are used for the purpose to increase fruit size and to change fruit shape in some cases. Few examples of those PGR are Cytokinins and Gibberellins. Application of Cytokinins and Gibberellins on the fruit increases the cell division during early stage of the fruit growth and also changes the shape of the fruit. Promalin is a mixture of PGR which contains 6-Benzyl adenine and GibberellinAcid₄₊₇ and it is used commercially in apple production. Application of Promalin during early stage of flowering and fruit development alter the

shape of the fruit from oblate to elongate as it enhances the cell division in calyx region. Clearly showing, the use of PGRs increases the fruit growth rate or the surface expansion rate and final fruit size.

The quality of fruit of an apple is adamant by its taste, aroma, color and shape, which is attained by each particular variety of apples. According to Marcelle (1995), the ration of fruit height/diameter (H/D) comprises a factor of fruit quality. The lack of typical shape was considered a marketing disadvantage. Before the harvest diverse range of manipulations and treatments can reduce such deformities. Promalin which is a mixture of GA₄₊₇ and

Benzyl adenine improves the shape of the fruit as it did chemical thinning at the end of the flowering period (William, 1978, Burak And Buyukyilmaz 1997). The aim of the study is to evaluate the effectiveness of CPPU along with promalin in different combination on increasing the fruit size, fruit shape and fruit surface area.

Materials and Methods

Apples (*Malus domestica* Borkh) cv. 'Pinova' was selected for this study. Apples were grown in an experimental orchard of the Horticultural Research Station of the Leibniz University Hannover at Ruthe (lat. 52° 14'N, long 9°49'E). 20 to 25 king flowers were retained per tree and remaining flowers were trimmed. Flowers were sprayed with 20 ppm CPPU (Forchlorfenuron; 1-(2-chloro 4 pyridinyl) 3- phenylurea) or 20 ppm Promalin (Gibberellic A₄₊₇ and 6-Benzyl adenine) or both (Table 1). Three treatments i.e., NO PGR, C1P2, and C2P2 were analyzed throughout the developmental stages till maturity. Other treatments i.e., No thinning, C1, C2, P1, P2, C1P1, C2P1 were analyzed only at the maturity.

Fruit were sampled randomly at 7 to 14 days interval starting from 35 days after full bloom (DAFB). Fruit which are free from any damage were harvested early in the morning. Fruit were kept in a box lined with moist filter paper and transported to the laboratory and are processed immediately on the day of harvesting or kept in cooling room for not longer than 24h.

Monitoring fruit growth

Fruit growth and development was monitored by using non-destructive method. In each treatments i.e., NO PGR, C1P2, C2P2 30 fruit were selected and tagged. Calibrated images of the fruit were taken at 1 to 2 weeks interval starting from petal fall till the maturity.

Calibrated images were analyzed using image analysis (Software Cell[^]P, Olympus Soft Imaging Solution, Munster, Germany). In the images the fruit was divided in to four equal sections and two diameters (largest and smallest) and height of each section was measured. The fruit surface (S) area was calculated according to Eq. 1.

$$S = 4F + \pi(r_c^2 + r_p^2) \dots \dots \dots (1)$$

In the equation F is the lateral surface area of a section, r_c^2 is the radius at calyx plain and r_p^2 is the radius at pedicel plain. F of each section was calculated using according to the following equation. 2.

$$F = (r_1 + r_2) \sqrt{(r_1 - r_2)^2 + h^2} \dots \dots \dots (2)$$

In this equation r_1 and r_2 are the radius across the fruit and h is the height along the fruit. Fruit surface growth rate was calculated using the regression parameters obtained from the sigmoidal regression line fitted through the plot of fruit surface areas vs. time (DAFB). Relative growth rate was calculated by dividing surface growth rate by the existing initial surface area of fruit.

Results and Discussion

The apple fruit treated with different plant growth regulators with various combinations have different surface area (Fig. 1). Fruit from NO-THINNING treatment have the lowest surface area. Surface area of the fruit from NO-PGR treatment have much higher than the surface area of NO-THINNING fruit but lower than the surface area of all other PGR treated fruit. The C2P2 fruit have the highest surface area among the all PGR treated fruit. Further, Surface areas of P1 or P2 fruit were generally similar to NO-PGR fruit. Whereas the surface area of C1, C2, C1P1, C2P1, and C1P2 fruit were similar but higher than that of P1 and P2 fruit.

Table.1 Description and schedule of application of plant growth regulators

Treatment	Description	Time of application
NO THINNING	Without thinning	
NO PGR	Thinned but no plant growth regulator application	
C1	Thinned + CPPU single spray	At full bloom
C2	Thinned + CPPU double sprays	At full bloom and 7 days after full bloom (DAFB)
P1	Thinned + Promalin single spray	At full bloom
P2	Thinned + Promalin double sprays	At full bloom and 7 DAFB
C1P1	Thinned + CPPU single spray and Promalin single spray	At full bloom and 7 DAFB
C2P1	Thinned + CPPU double sprays and Promalin single spray	At full bloom, 7, 14 DAFB
C1P2	Thinned + CPPU single spray and Promalin double sprays	At full bloom, 7, 14 DAFB
C2P2	Thinned + CPPU double sprays and Promalin double sprays	At full bloom 7, 14 and 21 DAFB

Fig.1 The surface area of untreated and PGR treated (CPPU or promalin or both with single or double application) mature ‘Pinova’ apple fruit. CPPU and promalin was applied after thinning of fruit lets leaving 20 to 25 fruit per tree

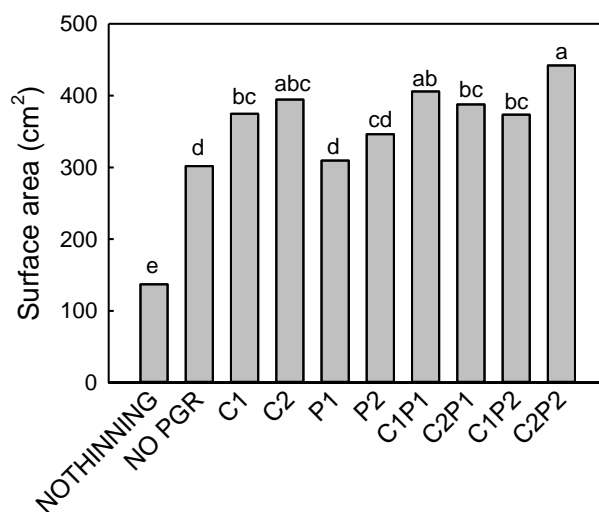
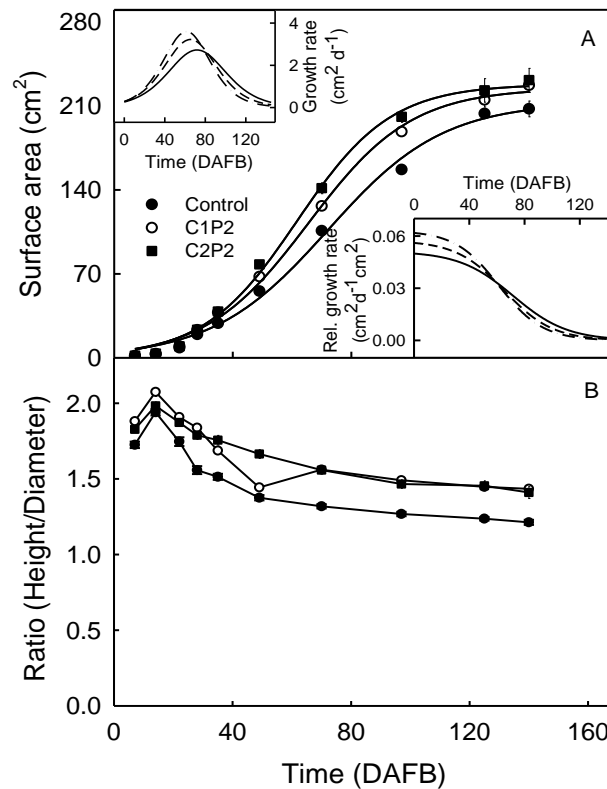


Fig.2 (A) The time course of change in fruit surface area of untreated (NO PGR) and PGR treated (C1P2, single application of 20ppm CPPU + double applications of 20ppm promalin; C2P2, double application of 20ppm CPPU + double applications of 20ppm promalin) developing ‘Pinova’ apple (main fig.). Fruit surface growth rate (inset upper left corner) and relative growth rate (inset lower right corner) as affected by time in days after full bloom (DAFB). (B) Time course of change in the ratio of height and diameter of fruit during of untreated and PGR treated developing ‘Pinova’ apple. Data points represent mean \pm SE



Fruit growth of an apple followed the sigmoid pattern (Fig. 2A). The growth was slow at the beginning and then increased rapidly till 100-120 days and very slow when it reached maturity. C2P2 has the highest fruit surface area while NO-PGR has the lowest fruit surface area during all stages of development. The surface area growth rate increased rapidly during the initial stage of growth of an apple and reached the peak at about 55 DAFB in C2P2, 60 DAFB in C1P2 and about 70 DAFB in NO-PGR fruit and then declined (Fig. 2A inset, upper left). The relative growth rate of fruit was very high at early stages of fruit growth and decrease continuously with time (Fig. 2A inset, lower right). C2P2 fruit had

the highest and NO-PGR had the lowest growth rate and relative growth of the fruit surface. The height/diameter ratio of apple increases at around 10 DAFB and then decrease continuously with the time (Fig. 2B). The ratio was high in C2P2 treated fruit while low in NO PGR fruit.

Data presented here has demonstrated that the combined application of CPPU and promalin (i) increased fruit surface growth rate and final surface area of the fruit. The fruit growth occurs continuously till the maturity. The results show that the growth was very high in the fruit which are treated with CPPU and promalin. The surface area of C2P2 fruit is

larger than those of NO PGR. At maturity fruit surface area was higher by 20-30% (Fig. 2). The growth rate of C2P2 has reached the peak first at 55 DAFB followed by C1P2 at 60 DAFB and NO PGR at 70 DAFB. The relative growth rate is very high at early stages and decreases continuously till maturity which is higher in C2P2 than NO PGR fruit and C1P2 is always being in between. The ratio of Height/Diameter of NO PGR, C1P2 and C2P2 are parallel throughout the development but C2P2 has the highest ratio while NO PGR showing fewer ratio. The fruit shape was elongated when treated with promalin (Demetrios *et al.*, 2004). The ratio of height and diameter of fruit is much higher when treated with cytokinins, gibberellin A₄ and A₇ than the control fruit (Unrath., 1978; Eccher and Boffelli., 1981; Curry and Williams., 1983; Burak and Buyukyilmaz., 1997). Time of application of PGRs also affects the shape of the fruit. PGR applied at full bloom and repeated applications at early stage considered as best treatment with higher fruit size, higher height diameter ratio and reduced russeting. This results is consistent with the results of Eccher and Boffelli(1981), Burak and Buyukyilmaz (1997), Steenkamp and Ina Westraad (1988). Similar observations were also made in destructive measurement where C2P2 fruit has 30-40% higher surface area than that of NO PGR fruit, where NO THINNING fruit has the lowest surface area amongst all the treatment (Fig. 1).

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