FLOWER AND FRUIT THINNING EFFECTS ON THE DEVELOPMENT AND QUALITY OF 'ŠAMPION' APPLE FRUITS

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A B S T R A C T

The influence of flower or fruit hand-thinning methods on fruit quality was estimated in the experiment conducted from 1997 to 1999, at the commercial orchard near Lublin in Poland. The experiment was carried out on 'Šampion' trees/M.26 planted in a bed system at 1 x 2 x 4 m spacing. The study was a complete randomized block design with a single-tree plot replicated eight times. In 1999, during the vegetative period, the dynamics of fruitlet growth were also observed. Fruitlets on trees subjected to flower thinning towards the end of the flowering period, were characterized as having a fast rate of growth in all separated subperiods. However, the control fruits, despite having quite a fast rate of growth in the first separated subperiod, showed the slowest rate of growth in the following two subperiods. Flower thinning at the pink bud stage, and towards the end of flowering had a beneficial influence on yield of fruit > 70 mm in diameter and mean fruit mass. The control trees gave the smallest yield of fruit > 70 mm in diameter. The control fruits were characterized as having a lower mean fruit mass. Fruits from trees subjected to flower thinning at the pink bud stage had the biggest P and K content, but tended to have the smallest Ca content and the biggest K/Ca ratio. The control fruits had the great Ca content and tended to have the lowest K/Ca ratio.

Key words: apple, fruitlet growth, P, K and Ca content

INTRODUCTION

The presence or absence of fruit in apple trees has a major effect on apple yield and quality of fruits. Effect of time and severity of flower or fruitlet thinning have been extensively studied to determine their influences on fruit quality at harvest (Krzewińska et al. 2002).

According to Link (2000) there are two groups of quality components. The first group includes size, colour, skin performance, firmness,

soluble solids, sugar and acid content. The second group includes calcium, phosphorus and potassium levels, which are important for storability and occurrence of physiological disorders.

Although much research has focused on the effect of thinning on yield or other production aspects, the fruit quality and fruitlet growth during the vegetation season appear as secondary issues. The purpose of this study was to find out how the time of hand thinning of flowers or fruitlets of apple trees cv. 'Šampion' influences the rate of fruitlet growth, and some final apple quality features.

MATERIAL AND METHODS

The experiment was carried out from 1997-1999 using five-year old trees cv. 'Šampion' (M.26 rootstock) in a commercial orchard, near Lublin, Poland. The trees were planted in a bed system 1 x 2 x 4 m. The trees were trained as a slender spindle to a height of 2.5 m. The interrows were grassed whereas herbicide strips (2 m wide) were kept along the rows. Tree protection against diseases and pests was carried out according to the recommendations for commercial orchards.

Hand thinning treatments were applied to flowers (at the pink bud stage, and towards the end of flowering) and to fruitlets, two weeks after full bloom. The flowers or fruits were thinned to 50% of their initial number (Tab. 1). After June drop, the fruitlets were thinned to one fruitlet per cluster with a space of about 20 cm between the fruitlets. Trees which were not thinned were left to be the control trees. The experiment was a complete randomized block design with a single-tree plot replicated eight times.

In the 1997-1999 period, the following data were taken at fruit maturity time:

- yield of fruit with diameter bigger than 70 mm (kg/tree);
- mean fruit mass (g) evaluated for 100 fruit sample from each treatment;
- flesh firmness measured using Magness-Taylor penetrometer (mod. FT 327) with 11,3 mm probe, as an average value from two measurements made at opposite fruit sides at equatorial zone (40 replications);
- content of P, K and Ca in fruits (% dry matter) determined using the following procedures: P colorimetrically, K and Ca by AAS.

Table 1. Treatments

	Methods of hand thinning
1.	At the pink bud stage, 50% of flower clusters removed
2.	Towards the end of flowering, 50% of flower clusters removed
3.	Two weeks after full bloom, 50% of fruit clusters removed
4.	After June drop: one fruitlet per cluster remained at a distance of 20 cm
5.	The control – no thinning

Additionally in 1999, during the vegetative period, the dynamics of fruitlet growth were observed. Using digital slide gauge the diameters of fruitlets were measured each week from 2nd of June to 30th of August (and from 6th July to 30th August on fruitlets from trees where thinning was made after June drop). Diameters of one hundred fruitlets from every treatment were determined. The measuring was always done on the same fruitlets. The chosen fruitlets came from the middle height of the tree crown, and two-year-old wood sites were used.

The data were subjected to analysis of variance and mean separation was by Tukey's test at $p = 0.05$.

RESULTS

Dynamics of fruit growth

Based on the fruitlet growth rate (FGR), the entire period of the investigation was divided into three subperiods (Fig. 1). The first subperiod (02.06–16.06) was relatively short and was characterized by a rapid FGR (8.1 mm/week) (Tab. 2); during the second subperiod (17.06-21.07) the FGR was reduced to about 4.6 mm/week. During the third subperiod (22.07-30.08) the FGR was even more reduced to 2.7 mm/week.

Diameter of fruitlets on the first measuring day (2nd June)

The diameter of fruitlets in the beginning of measuring characterized by similar values from most trees (Fig. 2).

Only fruitlets from trees, in which thinning was done towards the end of flowering, had significantly smaller diameters (16.04 mm) than in other treatments.

Rate of fruitlet growth in the first subperiod

Fruitlets from trees which were subjected to flower thinning towards the end of flowering were characterized by the highest FGR value. In comparison with the controls (Tab. 2) fruits from trees, where fruitlets were hand thinned two weeks after full bloom, and fruitlets from the control increased their diameter relatively quickly at FGR 8.08 and 8.07 mm/week, respectively. The slowest FGR, relative to the control, were fruit from trees thinned at the pink bud stage (7.6 mm/week).

Rate of fruitlet growth in the second subperiod

Apples from the control trees showed the slowest diameter increase (4.0 mm/week) compared to fruits from other treatments. Significantly higher FGR, relative to the control, were fruits from trees where thinning was done at the pink bud stage, after June drop, and towards the end of flowering (Tab. 2).

Rate of fruitlet growth in the third subperiod

In the third growth subperiod the highest FGR was observed for fruitlets from trees subjected to flower thinning at the pink bud stage, and towards the end of flowering. The FGR decreased, as the delay in the time of thinning decreased (Tab. 2). The control fruits had an increase

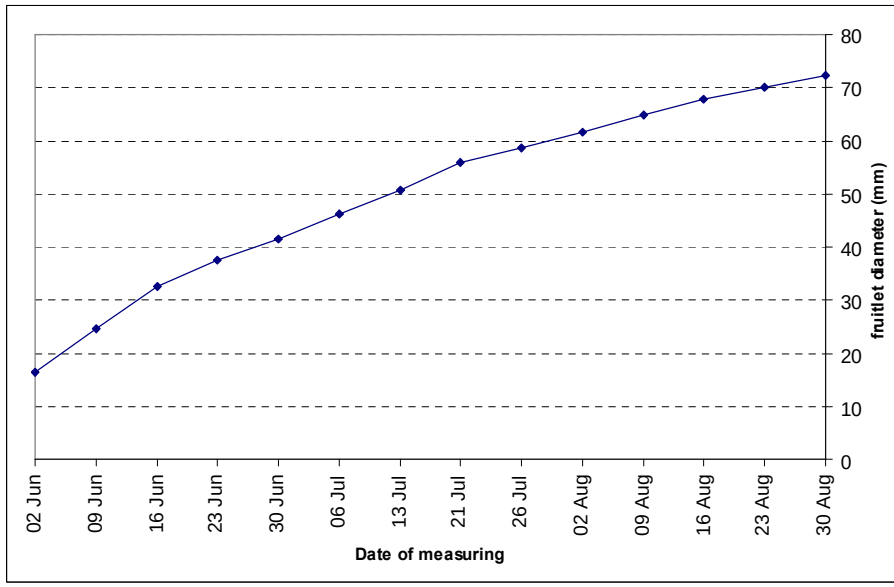

Figure 1. Fruit growth rate of apple cv. 'Šampion'. The vertical lines separate subperiods of fruitlet growth

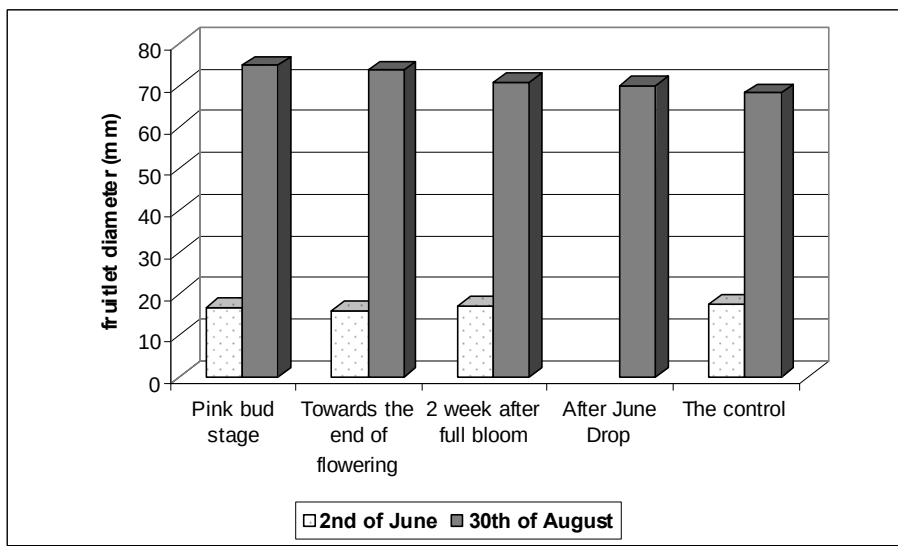

Figure 2. Fruitlet diameter at the first and the last date of measuring relative to time of thinning

Table 2. Fruit growth rate of cv. 'Šampion'/M.26, in the separated subperiods, depending on the time of hand thinning

Time of hand thinning	Weekly fruit growth rate (mm/week)		
	the first subperiod	the second subperiod	the third subperiod
Pink bud stage	7.6 a*	5.3 c	2.8 b
Towards the end of flowering	8.6 c	4.8 b	2.8 b
2 week after full bloom	8.1 b	4.3 ab	2.7 b
After June drop	-	4.9 bc	2.6 ab
The control	8.1 b	4.0 a	2.4 a
Mean for the subperiod	8.1	4.6	2.7

*Means within columns followed by the same letters are not significantly different at p = 0.05

in diameter that was significantly slower compared to fruits from trees subjected to flower or fruitlet thinning in the period from the pink bud stage to two weeks after full bloom. As for the rate of growth, on the last day of measurements (30th of August), the biggest diameter was from fruits of trees where flower thinning was done at the pink bud stage, and towards the end of flowering (Fig. 2).

Comparison of fruit quality depending on time of hand thinning

Hand thinning done at every examined time frame tended to result in a fruit yield increase (Tab. 3). This was significantly evident where trees were subjected to flower thinning towards the end of flowering.

Flower hand thinning at the pink bud stage and towards the end of flowering affected the mean fruit mass increase, in comparison with the control. Fruits from trees where fruitlets were thinned either two week after full bloom or after June drop had a slightly higher mass.

No significant differences in flesh firmness among the treatments were found (Fig. 4).

An estimation was made on the effect the time of thinning had, on the content of phosphorus in fruits. It was shown that only the treatment applied at the pink bud stage had an increasing effect on the P content as compared to the control.

There was no time in which the thinning significantly influenced the increase of K content in fruits as compared to the control. However, thinning applied two weeks after full bloom and after June drop resulted in a significantly lower fruit content of K than the control fruits.

Evaluating the effect the time of thinning had on fruit Ca content showed that a delay of thinning led to (the tendency only) increased Ca values. The greatest Ca content was found in the control fruits.

The different times of thinning had no significant effect on the fruit K/Ca ratio as compared to the control fruit.

Table 3. Effects of flower/fruit thinning of 'Šampion' trees on the yield of fruit > 70 mm in diameter, mean fruit mass and flesh firmness (average for 3 years)

Time of hand thinning	Yield of fruit > 70 mm in diameter [kg/tree]	Mean fruit mass [g]	Flesh firmness [MPa]
Pink bud stage	21.3 ab*	162.1 b	0.64 a
Towards the end of flowering	23.5 b	161.3 b	0.64 a
2 week after full bloom	20.8 ab	147.8 ab	0.66 a
After June drop	20.0 ab	148.9 ab	0.63 a
The control	18.4 a	134.8 a	0.59 a

*For explanations, see Table 2

Table 4. Effects of flower/fruit thinning of 'Šampion' trees on the content of P and Ca, K concentration and K/Ca ratio

Time of hand thinning	Content of P [mg kg^{-1}d.m.]	Content of K [% d. m.]	Content of Ca [mg kg^{-1}d.m.]	K/Ca ratio
Pink bud stage	691 b*	0.664 b	171 a	41.21 a
Towards the end of flowering	622 a	0.644 b	182 a	39.81 a
2 week after full bloom	602 a	0.563 a	181 a	38.28 a
After June drop	571 a	0.588 a	193 ab	36.28 a
The control	624 a	0.634 b	241 b	30.38 a

*For explanations, see Table 2

DISCUSSION

Apple fruit grows in two phases: an early exponential cell division phase that typically lasts for about 3-5 weeks after bloom, followed by the cell expansion phase which lasts for the rest of the season (Bollard, 1970; Pratt, 1988). The early exponential growth is related to the exponential increase in light interception as leaves are produced. After canopy closure, the light interception becomes constant, and the growth is a linear function of light availability.

The growth pattern of the apple fruit has generally been described as sigmoidal (Blanpied, 1966; Assaf et al., 1982), especially if diameter is the measure of growth. In this study the diameter of the fruitlets data, versus the time data, also show a late–season decline in fruit growth rates. The rate of fruitlet growth, in three separated subperiods, was diverse when time of thinning was taken into consideration. The best difference was observed in the first two weeks of June. However, the last measurements of fruitlets from trees subjected to thinning at the pink bud stage, towards the end of flowering, and two week after flowering, all showed a similar rate of growth. The

control fruits, despite beginning with a fast rate of growth, slowed down in the two following separated periods, and then showed the slowest rate of growth. The control fruits also had the smallest diameter in the last measuring term.

Research on apple thinning and anatomy has shown that the effects of several different timings of thinning led to differences in final fruit size. These differences were most closely associated with differences in cell numbers in the cortex (Goffinet et al., 1995). Berg (1985) stated that smaller fruit produced by heavily cropping trees can thus be attributed to low cell number. Other workers have also indicated that cell number is a more important component determining final fruit size (Bain and Robertson, 1951; Pearson and Robertson, 1953; Batjer et al., 1958). However, thinning practices aimed at normalizing cropping levels are usually done after June drop; after cessation of cell division. The time of thinning had a great influence on mean fruit mass. Mean fruit mass was significantly related to time of hand thinning. In this study, there was a reduction in mean fruit mass when time of hand thinning was delayed. Flower thinning at the pink bud stages, and towards the end of flowering, had a significant effect on the heaviest fruit. Other workers have also detailed this results (Jones et al., 1992). Flower thinning increased the yield of fruit with diameter bigger that 70 mm, especially if thinning was made at the end of flowering (Nielsen and Dennis, 1999; Bangerth, 2006). Wieniarska et al. (2000), Szot (2007) and Wociór (2008) reported that date of thinning had an effect on the obtained commercial yield increase of 'Šampion' apples. Earlier thinning usually gave better results.

Increasing fruit load on apple trees increased dry matter production per unit leaf area and amount of dry matter partitioned into the crop (Palmer, 1992). However, apples from trees subjected to flower or fruitlet thinning contain a higher percentage of dry matter and the latter has been associated with increased strength of the fruit cortical tissue as measured instrumentally (Johnson, 1992). In this study, the flower or fruitlet thinning slightly increased flesh firmness as compared to the control. Johnson (1994) stated that the firmness of the population of fruit on the tree was increased by thinning, as evidenced by an overall positive correlation between mean fruit mass and mean firmness.

Some of research workers pointed out that fruit thinning resulted in fruits with higher K (Sharples, 1968) and lower Ca contents (Marcelle et al., 1989). In this study, apples from trees subjected to flower thinning at the pink bud stage had the highest P and K content. The control fruits had the highest Ca content and the lowest K/Ca ratio. High K and low Ca in fruit may be considered to be adverse in relation to storage, but higher P in fruits from trees subjected to early thinning is likely to be beneficial in reducing susceptibility to low temperature injury (Johnson and Yoga-

ratnam, 1978). Further experiments are required to determine if such the side effects of thinning could be balanced by pre- or post–harvest Ca supplementing.

CONCLUSION

1. Fruitlets on trees subjected to flower thinning at the end of flowering had fast rate of growth in all separated subperiods. However, the control fruits, despite quite a fast rate of growth in the first separated subperiod, showed the slowest rate of growth in the next two subperiods.
2. Flower thinning at the pink bud stage and towards the end of flowering had the most beneficial influence on yield of fruit with diameter bigger than 70 mm, and mean fruit mass. The control trees gave the smallest yield of fruit with diameter bigger than 70 mm and control fruits had the lowest mean fruit mass.
3. Fruits from trees subjected to flower thinning at the pink bud stage tended to have the biggest P and K content, but the smallest Ca content and the biggest K/Ca ratio. The control fruits had the greatest Ca content and tended to have the lowest K/Ca ratio.

REFERENCES

Assaf R., Levin I., Brando B. 1982. Apple fruit growth as a measure of irrigation control. HORTSCIENCE 17: 59-61.

Bain J.M., Robertson R.N. 1951. The physiology of growth in apple fruits. AUST. J. SCI. RES. 4: 75-91.

Bangerth F. 2006. Flower induction in perennial fruit trees: still an enigma? ACTA HORT. 727: 177-195.

Batjer L.P., Billingsley H.D., Westwood M.N., Rogers B.L. 1958. Predicting harvest size of apples at different times during the growing season. PROC. AM. SOC. HORT. SCI. 70: 46-57.

Bergh O. 1985. Effect of previous crop on cortical cell number of *Malus domestica* cv. Starking Delicious apple flower primordia, flowers and fruit. S. AFR. J. PLANT SOIL. 2: 191-196.

Blanpield G.D. 1966. Changes in the weight, volume and specific gravity of developing apple fruits. PROC. AM. SOC. HORT. SCI. 88: 33- 37.

Bollard E.G. 1970. The physiology and nutrition of developing fruits. In: Hulme A.C. (ed.) The Biochemistry of Fruits and Their Products, vol. 1. Academic Press, London, pp. 387-425.

Goffinet M.C., Robinson T.L., Lakso A.N. 1995. A comparison of 'Empire' apple fruit size and anatomy in unthinned and hand–thinned trees. J. HORT. SCI. 70: 375-387.

Johnson D.S. 1992. The effect of flower and fruit thinning on the firmness of 'Cox's Orange Pippin' apples at harvest and after storage. J. HORT. SCI. 67: 95-101.

Johnson D.S. 1994. Influence of time of flower and fruit thinning on the firmness of 'Cox's Orange Pippin' apples at harvest and after storage. J. HORT. SCI. 69: 197-203.

Johnson D.S., Yogaratnam N. 1978. The effects of phosphorus sprays on the mineral composition and storage quality of Cox's Orange Pippin apples. J. HORT. SCI. 58: 171-178.

Jones K.M., Bound S.A., Koen T.B., Oakford M.J. 1992. Effect of timing

of hand thinning on the cropping potential Red Fuji apple trees. AUST. J. EXP. AGRIC. 32: 417-420.

Krzewińska D., Basak A., Mika A. 2002. Effect of fruit set regulation on return bloom in some apple cultivars. ANN. UNIV. MARIAE CURIE–SKŁODOWSKA SEC. EEE HORTIC. 10: 221-227.

Link H. 2000. Significance of flower and fruit thinning on fruit quality. Special issue: Abscission and thinning of young fruit – from molecular to applied aspects. PLANT GROWTH REGUL. 31: 17-26.

Marcelle R.D., Porreye W., Deckers T., Simon T., Goffings G., Herregods M. 1989. Relationship between fruit mineral composition and storage life of apples cv. Jonagold. ACTA HORT. 258: 373-378.

Neilsen J. C., Dennis F.G. 1999. Effect of seed number, fruit removal, bourse shoot length and crop density on flowering in 'Spencer Seedless' apple. ACTA HORT. 527: 137-146.

Palmer J.W. 1992. Effects of varying crop load on photosynthesis, dry matter production and partitioning of Crispin/M.27 apple trees. TREE PHYSIOL. 11: 19-33.

Pearson J. A., Robertson R.N. 1953. The physiology of growth in apple fruits. AUST. J. SCI. RES. 6: 1-20.

Pratt C.S. 1988. Apple flower and fruit: morphology and anatomy. HORT. REV. 10: 273-308.

Sharples R.O. 1968. Fruit thinning effects on the development and storage quality of 'Cox's Orange Pippin apple fruits. J. HORT. SCI. 43: 359-371.

Szot I. 2007. Influence of intensity of hand thinning of fruitlets on fruit quality of cv. Szampion. ROCZNIKI AR W POZNANIU, OGRODNICTWO 41: 395-402.

Winiarska J., Basak A., Szember E., Murawska D. 2000. Studies of yielding and fruit quality after fruit set thinning. ZESZ. NAUK. AR W KRAKOWIE 364: 287-291.

Wociór S. 2008. Influence of hand thinning of flowers and fruits on yielding and fruit quality of apple cultivar Szampion. ACTA AGROBOT. 61 (2): 141-146.

WPŁYW PRZERZEDZANIA KWIATÓW LUB ZAWIĄZKÓW JABŁONI ‘SZAMPION’/M.26 NA WZROST I JAKOŚĆ OWOCÓW

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S T R E S Z C Z E N I E

W doświadczeniu prowadzonym w latach 1997-1999 w sadzie prywatnym w okolicach Lublina badano wpływ kilku sposobów ręcznego przerzedzania kwiatów lub zawiązków na jakość owoców na jabłoniach odmiany ‘Szampion’/M.26, w systemie pasowym w rozstawie 1 x 2 x 4 m. Doświadczenie założono w układzie kompletnej randomizacji, w ośmiu powtórzeniach, gdzie pojedyncze drzewo traktowano jako powtórzenie. Dodatkowo w 1999 roku w ciągu sezonu wegetacyjnego badano tempo wzrostu zawiązków. Zawiązki z drzew, gdzie kwiaty przerzedzano w końcu kwitnienia, we wszystkich wydzielonych podokresach, rosły w szybkim tempie. Natomiast owoce kontrolne, pomimo szybkiego wzrostu zawiązków w pierwszym podokresie, wykazywały najsłabsze tempo w kolejnych dwóch podokresach. Przerzedzanie kwiatów pod koniec kwitnienia i w fazie różowego pąka miało korzystny wpływ na plon owoców o średnicy > 70 mm. Drzewa kontrolne wydały najmniejszy plon owoców o średnicy > 70 mm, a ich owoce miały najmniejszą masę. Owoce z drzew poddanych przerzedzaniu kwiatów w fazie różowego pąka posiadały najwięcej P i K, ponadto wykazały tendencję do najniższego stężenia Ca i największego stosunku K/Ca.

Słowa kluczowe: jabłka, wzrost zawiązków, zawartość P,K i Ca