Scientific Papers. Series B, Horticulture. Vol. LX, 2016
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

A BRIEF OVERVIEW OF HAND AND CHEMICAL THINNING OF APPLE FRUIT

Alina Viorica ILIE[1], Dorel HOZA[1], Viorel Cătălin OLTENACU[2]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest,
59 Mărăşti Blvd., District 1, Bucharest, Romania
[2]Research Station for Fruit Trees Growing Băneasa, Bd. Ion Ionescu de la Brad, No. 4,
District 1 Bucharest, Romania

Corresponding author email: alisa_ilie@yahoo.com

Abstract

A brief overview of the fruit thinning effect on apple fruit quality is presented in the current paper. Handy and chemical fruit thinning has been previously studied, existing many published reports in literature that examine various aspects of this technological procedure. The state of the art in the field of apple thinning reveal that this operation can improve fruit size, increase return bloom and reduce alternate bearing habit of apple trees.

Key words*: apple, quality, thinning, fruit, blossom.*

INTRODUCTION

Apple thinning can be done in different ways: handy, chemicaly or mechanicaly.

Apple is characterized by heavy bloom and heavy set of fruits throughout the growing season with several negative consequence associated with small, poorly coloured, low quality fruits. Furthermore, flower bud formation for the following year is significantly reduced, resulting in low cropping and inferior quality fruit that has a reduced postharvest storage life. Thinning of the fruitlets is the removal of a portion of the crop before it matures on the tree to increase the marketability of the remaining fruit and to break the biennial bearing tendency of the tree (Greene, 2002).

Fruit thinning can improve fruit size, increase return bloom and reduce alternate bearing habit of apple trees.

Chemical and hand contribution on maintain the physiological balance between growth and fruiting and increasing the quantity and quality of fruit (Vămăşescu and Bălan, 2014).

Frequently, apple trees bloom abundantly and set too many fruits to optimize fruit size and return bloom. Therefore, most producers attempt to increase fruit weight by reducing the number of fruits on a tree (Treder, 2008).

Chemical thinners include different chemicals, but plant growth regulators and some insecticides are used for thinning in most cases. Result from the recently published literature point to advantages of combining certain growth regulators and insecticides for thinning. Combination of carbaryl and 1-naphtaleneacetic acid has given good results in some years but caused excessive thinning in others (Rogers, 1977).

Chemical thinning is important measure for the profitable agricultural production of fruits. Chemical thinning provides a good yield potential for the following vegetation. Thinning the apple crop during the post bloom period is absolutely essential to ensure large fruit size, superior fruit quality, and reliable annual cropping (Peşteanu, 2015).

Most of the thinning literature is focused on the effect of thinners on yield or other production aspects, while the fruit quality becomes a secondary issue (Jemrić et al., 2005).

Jemrić et al. (2003) cited on Link (2000) have reviewed the Germany experience with chemical thinning accumulated over three decades and concluded that there are two groups of quality components. First group includes size, colour, skin performance, firmness, sugar and acid content. The second group includes calcium and potassium levels which are important for storability and

occurrence of physiological disorders. Thinning intensity differently affects these two groups, therefore it is important to select an optimal thinning strategy by growing and local market conditions.
Hand thinning of the apple trees can be very accurate, but it is extremely expensive and requires skilled labor inputs (Costa et. al, 2001).

MATERIALS AND METHODS

A literature search strategy was used, starting on the older to the recent scientific papers on the hand and chemical thinning of apple fruit.

RESULTS AND DISCUSSIONS

Modern fruit thinning studies focus on the relationships between the thinning agent or combination of agents, thinning parameters such as the rate and timing of the application, and the effects on crop load (a measure of fruiting density typically expressed as number of fruit per trunk or branch cross-section area, or per tree canopy volume), fruit size (expressed as weight or diameter), fruit quality, and return bloom (the crop for the following year) (Davis, 2004).
Hand thinning of fruits is a very important process in fruit culture because it is a method of obtaining the optimum quantity of fruits, which have high physical and chemical qualities (Iordanescu et al., 2009).
Hand thinning is a common and high cost practice, not only due to the labor involved, but also because seedling and viguros clonal rootstock result in large trees (Reyes et al., 2008).
Iwanami et al. (2015) examined the efficiency of hand thinning on some apple cultivars. They reported that time required for hand thinning were very similar among clusters with four, five, or six flowers/fruitlets, which was twice as long as that required for clusters with two or three flowers/fruilets. They also concluded that time required for hand thinning cluster of axillary buds became significantly longer from bloom to 7 days after bloom and then decreased gradually from 7 to 25 days after bloom.
Chemical fruit thinning methods were tested by different researchers in many countries. Generally, plant growth regulators are used such as NAA, NAD, BA and ethephon for fruit tinning (Peşteanu, 2015).
In the literature there is information on the effect of different plant regulators in the chemical thinning of apple.
Naphthaleneacetic acid (NAA) is an auxin type thinner and was the first hormone type thinner used commercially (Stopar et al., 2007). The most effective time to apply NAA as a chemical thinner is when fruit diameter is 10-12 mm.
Synthetic cytokinin 6-benzyladenine (BA) has been found to be a good thinning agent. BA it is most effective if applied when fruit diameter averages about 10 mm and has a positive influence on return bloom, reduced the crop load and increased the fruit size (Greene, 2002; Robinson et al., 1998).
Naphthaleneacetamide (NAD) has long been in use, it acts as a synthetic auxin. NAD is considered to be a weak thinning agent who does not give satisfactory results if used alone (Stopar, 2006).
NAD induces early mild thinning, which starts the differentiation process among the flower cluster (Peşteanu, 2015).
Ethephon has long been used as a thinning agent. The main advantages of ethephon are that it greatly improves return bloom and that it can be applied over a longer period (Stopar, 2006).
The thinning response to chemical agents can be highly variable among cultivars and is strongly influenced by environmental conditions.
Weather, timing, choice of chemicals and concentration affect chemical thinning (Autio et al., 2005).
Šebek (2014) tested several thinning procedures comparing applications of NAA and BA in different concentration on three cultivars of apples. All treatments of NAA and NAA + BA had a positive effect on thinning of fruits, in terms of fruit weight and number of fruits per unit cross-sectional area of the trunk.
The highest reduction in ‘Golden Delicious’ fruit set was found on the NAA – sprayed trees, when evaluated at 45 days after full bloom (Reyes et al., 2008).
Peşteanu (2015) tested NAD (Geramid-New) and ethephon agents on ‘Idared’ apple variety.

The effect of the treatments with Geramid-New in dose 1.5 l/ha and Cerone 480 SL in dose of 0.3 l/ha had a positive effect on the number of inflorescences ant the placement of fruits in the trees crown. Also, these agents had an essential influence on quality of production.

NAD did not reduce fruit set. NAD also had no effect on fruit growth, and did not cause an increase in the proportion of pygmy fruit. NAD applied alone can not be recommended for thinning 'Fuji' apple trees (Stopar, 2006).

Wertheim (2000) mentions that NAD cannot be used on 'Delicious' trees because it induces the formation of a high number of pygmy fruit which stay on the tree until harvest time.

Radivojević et al. (2011) reported several experiments thinning two apple cultivars 'Gala' and 'Granny Smith', by hand and NAA and carbaryl. Average fruit size was consistently increased, especially in cv. 'Granny Smith'. A high return bloom was recorded in cv. 'Granny Smith' than cv. 'Gala'.

Šebek (2015) cited on Marini (2002) states that it is very difficult to adequately apply the procces of thinning in spur varieties from the Red Delicious cultivar, and that the use of NAA obtained satisfactory result in terms of fruit size and share of small fruits.

Milić et al. (2011) reported that the number of fruits per native branchet, fruit weight, fruit diameter and height yields, the best results in the chemical thinning of apple cultivar 'Golden Delicios' were obtained using BA in the concentration of 200 mg/L.

Turk and Stopar in 2010, studied the effect of 6-benzyladenine on apple thinning of cultivars 'Golden Delicious' and 'Idared'. The authors reported that BA sprayed at 10 mm did not support the findings contained in many reports which indicated that the best application time coincides with about 10 mm stage of fruit development (Greene, 2002). They concluded that BA can be active as a thinner in a wider period of phonological stages, from the end of bloom up to 20 mm of fruit diameter.

Single application of thinning agents ethephon 200 ppm at ballon stage and NAA 10 ppm or BA 100 ppm at 10 mm fruitlet diameter did not cause thinning response of 'Golden Delicious' (Stopar et al., 2007).

Recently, Peşteanu (2015) tested combination 6-BA and NAA. Therefore, it was established that the combined application of BA + NAA influenced on the nymber of inflorescences formed in the tree crown. Simultaneously the weight of single fruits increased from 16.8 to 28.2%, registering more favorable values where it was tested the combination of BA 100 ppm + NAA 10 ppm.

Significantly increased fruit weight resulted in the combined use of BA + NAA (Šebek, 2014).

Šebek (2015) reported the effect of single or combined use of products based on NAA and BA in thinning of the cultivars 'McIntosh', 'Jonathan' and 'Prima'. The author reported a significant reduction in the yield of 'Prima' apple fruits had the NAA 17.82 ppm treatment. Significantly higher yield compared to the control was determined by combined application of BA 100 ppm + NAA 4.29 ppm. Cultivar 'Prima' show a positive relation between the crop load and yield efficiency. The application of all treatments (individual application of NAA and combination of NAA + BA) in thinning cultivar 'McIntosh' has led to an increase in fruit weight. The application of NAA and NAA + BA combination of all treatments in thinning of fruits of 'Jonathan' cultivar has led to a statistically significant increase in fruit weight and statistically significant decrease in yield and total number of fruits per unit cross-sectional area of the trunk in relation to the control.

Yildirim-Akinci (2014) noticed that the combination of BA+GA_{4+7} is highly effective on fruit size when applied before cell division completed. It also increased fruit diameter, fruit lengh and fruit shape. The application of 100 ppm BA + GA_{4+7} was significantly increased fruit weight by 37% and improved the fruit shape.

Greene et al. (2006) applied a new BA thinning product, respectively MaxCel. This contains no gibberellins, contains more BA, the label was changed to apply more active ingredient, and the formulation was changed to improve foliar penetration and increase formulation stability. MaxCel significantly increased fruit weight at harvest.

Thinning showed no effect on fruit shape of apple cultivars 'Empire', 'Jon-A-Red', 'Braeburn" (Ouma and Matta, 2003).

Meland (2009) mentioned that it was more difficult to adjust the crop load at first bloom

than at the 20-mm fruitlet stage due to higher levels of fruit drop at first bloom. This was confirmed, where thinning at first bloom, rather than at the 20 mm fruitlet stage, improved the mean fruit weight and fruit quality, when comparing similar crop levels. Thinning at first bloom gave an annual crop of high quality.

The author Basak (2006) reported that on 'Gala' trees need to be intensively thinned. Because they blossom over a long period, the fruitlets are at different stages of development at thinning time. Thinning is most effective when too or more preparations are used in sequence. Thus, fruit quality was particularly good when BA was mixed with carbaryl or applied after NAA. In case of mixture of BA and carbaryl, yield and fruit size were better, but color was worse. When BA was used with NAA, fruit color was the same but refractive index was lower.

Peşteanu (2015) reports that in case of using BA 100 ppm + NAA 10 ppm application it was registered a decrease of fruit production, but and increase of their quality. Increasing the dose of BA 140 ppm + NAA 14 ppm does not permit fruit development in comparison with the previous variant. This is explained by the fact of pygmy fruit type appearance, diminishing the fruit number per a tree, average weight and diameter decreases, finally influencing the fruit production quantity and quality.

NAA has shown a strong thinning effect in spur-type 'Red Delicious' trees, but it may also induce an excessive development of pygmy fruits (Marini, 1996).

Milić et al. (2012) reported several experiments thinning three apple cultivars 'Braeburn' and 'Camspur' with NAA and BA. Thinning with NAA and BA has a potential risk of oversized fruits in 'Braeburn' and abnormally small (pygmy) fruit occurrence in 'Camspur'. The average fruit weight was increased, while effects of thinning on fruit parameters in 'Braeburn' were not consistent.

When ethephon was sprayed at a dose of 200 ppm did not reduce fruit set. When used alone, ethephon had no significant effect on mean fruit weight and fruit size distribution (Stopar, 2006).

Stopar et al. (2007) reported that spraying of ethephon at 200 ppm at the balloon stage slightly reduced the fruit number per tree at harvest time.

Al-Absi (2009) related that the ethephon at 500 ppm in absence or presence of BA at 200 ppm significantly increased the number of fruits per cm^2 trunk cross sectional area. A positive correlation existed between intensity of fruitlet thinning and fruitlet retention. These results are in agreement with that of Stopar and Lokar (2003), who reported that ethephon, BA and their combination significantly increased flower bud retention of 'Summerred' apples.

When ethephon treatment was followed up by BA treatment after blossoming, the thinning rate did not increase. Results were best when ethephon treatment was followed up by NAA treatment (Basak, 2006).

Marini (2004) applied combination of ethephon and Accel for thinning 'Delicious' apple trees. BA applied to 'Delicious' and 'Golden Delicious' at 11 to 12 mm fruit diameter reduced fruit set, and fruit weight and length/diameter ratio increased with concentration. The direct effect of Accel and ethephon on fruit weight appears to be inconsistent. Accel did not improve return bloom, even when trees were adequately thinned.

Iordănescu et al. (2009) cited on Cepoiu (1978) which reports that when hand thinning is done sometime in June, after the physiological fall of apples when they have 3-4 cm diameter, it has a good influence upon fruits physical and chemical qualities, but a very small impact upon buds differentiation.

Stopar et al. (2007) has noted that hand thinning performed at the end of June drop resulted in a reduced final number of fruit per tree and an increased mean fruit weight, but they were not significant. Hand thinning should be done more rigorously to reach the commercial fruit size about 150 g per fruit.

CONCLUSIONS

Fruit thinning is intended to address both horticultural and economic concerns as the grower simultaneously seeks to protect the tree from damage due to excess cropping, ensure adequate return bloom, and increase the number of larger, more valuable, fruit both in the current year and subsequent years (Davis, 2004).

The few studies summarized in this review illustrate that the effects of fruit thinning differ widely and successful thinning, resulting in increase fruit size, increased yield and improved certain parameters of the apple quality.

REFERENCES

Al-Absi K.M., 2009. Thinning intensity of 'Ace Spur Delicious' and 'Idared' apples with ethephon, benzyladenine and thei combination. Jordan Journal of Agricultural Sciences, 5(3):237-250.

Autio W.R., Krupa J., Greene D.W., 2005. Late-season chemical thinning of apples. Fruit Notes, 70:1-5.

Basak A., 2006. The effect of fruitlet thinning on fruit quality parameters in the apple cultivar 'Gala'. Journal of Fruit and ornamental Plant Research. 14(2):143-150.

Costa G., Corelli-Grappadelli L., Bucchi F., 2001. Studies on apple fruit abscission and growth as affected by cytokinins. Acta Horticulturae, 557:213-249.

Davis K., Stover E., Wirth F., 2004. Economics of fruit thinning: a review focusing on apple and citrus. Hortechnology, 14(2):282-289.

Greene D.W., 2002. Chemicals, timing, and environmental factors involved in thinner efficacy on apple. HortScienec., 37:477-481.

Greene D.W., Krupa J., Vezina M., 2006. Effect of MaxCel on fruit set, fruit size, and fruit characteristics of Summerland McIntosh apples, 2005 results. Fruit Notes, 72:12-15.

Iordănescu O., Szonyi I., Micu R., Mihuţ C., 2009. Researches concerning the influence of manual thinning of Romus 2 apples in conditions of Timisoara. Journal of Horticulture, Forestry and Biotechnology, 13:295-298.

Iwanami H., Moriya-Tanaka Y., Honda C., Wada M., 2015. Efficiency of hand-thinning in apple cultivars with varying degrees of fruit abscission. The Horticulture Journal, 84(2):99-105.

Jemrić T., Pavićić N., Blašković D., Krapac M., Pavičić D., 2003. The effect of hand and chemical fruit thinning on 'Golden Delicious Cl. B' apple fruit quality. Current Studies of Biotechnology, 3:193-198.

Jemrić T., Pavičić N., Skendrović M., 2004. Influence of thinning method on postharvest quality of ‚Golden Delicious Cl. B' apple (Malus domestica Borkh.). Agriculturae Conspectus Scientificus, 70(1):11-15.

Link H., 2000. Significance of flower and fruit thinning on fruit quality. Plant Growth Regul, 31:17-26.

Marini R.P., 1996. Chemically thinning spur ‚Delicious' apples with carbaryl, NAA, and ethephon at various stages of fruit development. HortTechnology, 6:241-246.

Marini R.P., 2002. Thinning 'Golden Delicious' and spur 'Delicious' with combinations of carbamates and NAA. HortScience, 37(3):534-538.

Marini R.P., 2004. Combinations of ethephon and accel for thinning ‚Delicious' apple trees. J. Amer. Soc. Hort. Sci. 129(2):175-181.

Meland M., 2009. Effects of different crop loads and thinning times on yield, fruit quality, and return bloom in Malus domestica Borkh. ‚Elstar'. Journal of Horticultural Science &Biotechnology, 171-121.

Milić B., Keserović Z., Magazin N., 2011. Production effects of chemical fruit thinning in young apple orchards. Agricultural Economics, 58:133-146.

Milić B., Keserović Z., Magazin N., Dorić M., 2012. Fruit quality and bearing potential of chemically thinned 'Braeburn' and ‚Camspur' apples. Žemdirbysté Agriculture, 99(3):287-292.

Ouma G., Matta F., 2003. Response of several apple tree cultivars to chemical thinner sprays. Fruits, 58(5):275-281.

Peşteanu A., 2011. Effect of thinning 'Idared' apple variety using NAD and ethephon. Lucrări Ştiinţifice Seria Horticultură, 58(1):129-134.

Peşteanu A., 2015. The influence of thinning agent on base of 6-BA and NAA on productivity and fruit quality of ‚Gala Must' variety. Bulletin UASVM Horticulture, 72(1):151-153.

Radivojević D., Zabrkić G., Milivojević M.J., Veličković M., Oparnica Č., 2011. Effect of chemical and hand thinning young apple tree on yield and fruit quality. Proceedings.46th Croatian and 6th International Symposium on Agriculture. Opatija, Croatia, 1044-1047.

Radivojević D., Milivojević M.J., Oparnica Dj. Ć., Vulić B. T., Djordjević S.B., Ercişli S., 2014. Impact of early cropping on vegetative development, productivity, and fruit quality of Gala and Braeburn apple trees. Turkish Journal of Agriculture and Forestry, 38:773-780.

Reyes D.I.B., Chaćon A.R., Campos Á.R.M., Prieto V.M.G., 2008. Apple fruit chemical thinning in Chihuahua, Mexico. Rev.Fitotec.Mex., 31(3):243-250.

Robinson T., Lakso A., Stover E., Hoying S., 1998. Practical apple thinning programs for New York. New York fruit quarterly, 6:14-18.

Rogers BL, Williams GR., 1977. Chemical thinning of spur-type Delicious apple fruit. Virginia Fruit, 65:23-28

Stopar M., Lokar V., 2003. The effect of ethephon, NAA, BA and their combinations on thinning intensity of ‚Summered' apples. Journal of Central Agriculture, 4:399-403.

Stopar M, 2006. Thinning of ‚Fuji' apple trees with ethephon, NAD and BA, alone and in combination. Journal of Fruit and Ornamental Plant Research, 14:39-45.

Stopar M., Schlauer B., Turk Ambrožič B., 2007. Thinning ‚Dolden Delicious' apples using single or combining application of ethephon, NAA or BA. Journal Central European Agriculture, 8(2):141-146.

Šebek G., 2014. Application of NAA and BA in chemical fruit thinning of autochthonous cultivars of apple. Journal of Agricultural Science and Technology, 4:21-28.

Šebek G., 2015. Application of NAA and BA in chemical thinning of some commercial cultivars of apple. Acta Agriculturae Serbica, XX, 39:3-16.

Treder W., 2008. Relationship between yield, crop density coefficient and average fruit weight of 'Gala' apple. Journal of Fruit and Ornamental Plant Research, 16:53-63.

Treder W., Mika A., Krzewińska D., 2010. Relations between tree age, fruit load and mean fruit weight. Journal of Fruit and Ornamental Plant Research, 18(2):139-148.

Turk B.A., Stopar M., 2010. Effect of 6-benzyladenine application time on apple thinning of cv. 'Golden Delicious' and cv. 'Idared'. Acta agricuturae Slovenica, 95(1):69-73.

Vămăşescu S., Bălan V., 2014. Thinning and foliar fertiliyation influence on the zield of Idared apple cultivar. Scientific Papers. Seria B, Horticulture, LVIII:107-110.

Wertheim S.J., 2000. Developments in the chemical thinning of apple and pear. Plant Growth Regulation, 31:85-100.

Yildirim-Akinci F., Kepenek G., Şan B., Zildirim A.N., Kacal E., 2014. Effects of BA+GA $_{4+7}$ treatments on fruit qualitz in 'Fuji' apple variety. Turkish Journal of Agricultural and Natural Sciences, 2:1387-1390.