Effects of Fruitlets Thinning on Yield and Crop Load of the "Jonagored" Apple Cultivar

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Abstract

The study on effects of fruitlets thinning method on quality indicators of "Jonagored" apple cultivar, was carried out during the period 2013-2015, in Skivjan, Gjakova. Two different fruitlets thinning methods (hand thinning and chemical thinning using a combination of Carbaryl 1000 ppm + NAA 40 ppm, with 1200 L ha^{-1} spraying solution) and two replications, with 10 apple trees for each variant on each replication for each system shape, were used. Fruitlets thinning was carried out 15 days after bloom, when fruit diameter was 10-12 mm. At the harvest time, there were weighted the apples of each apple tree and was calculated the yield of each treatment (each thinning method), while the volume of crop load was measured after leaves drop. Observed results showed that fruitless thinning method have significantly affected the yield and crop load of "Jonagored" apple cultivar of both training systems (slender spindle and improved pyramidal shapes). Chemical thinning of slender spindle apple trees showed a raise of the volume of crop load by 0.508 m^3 per apple tree or 12%, while the yield was increased by 3.75 kg per apple tree. At the same time, the chemical thinning of the improved pyramidal system apple trees showed a raise of the volume of crop load by 1.62 m^3 per apple tree or 12.7%, while the yield was increased by 4.88 kg per apple tree. The observed results were statistically confirmed by Anova-test ($p \leq 0.05$), where $F = 12.17216 > F_{crit} = 3.738892$ and P-value = 0.00044 < α = 0.05, which mean that the relationship between fruitlets thinning and measured indicators (crop load and yield) was significant.

KEYWORDS: apple, fruitlet, chemical thinning, crop load, hand thinning, "Jonagored", yield, Naphthalene Acetic Acid (NAA).

Introduction

Most apple cultivars have an over-abundant flower density and percentage fruit set. Fruit thinning is a production practices to regulate the numbers of flowers or fruitlets are therefore necessary to overcome alternate bearing and to enhance fruit quality (Çakalli and Thomaj, 2005).
Fruit thinning of apple and to the other fruit trees can be achieved mechanically, by hand (which is a very high labor cost practice, used mainly to new orchards and in limited areas), or by applying plant growth regulators at first bloom or at the fruitlet stage (Ferraj

and Thomaj, 2014; Stopar, 2004). The most common treatment is a combination of chemical thinning followed by hand-thinning, for a final adjustment to the correct crop load (Meland, 1997). According to Meland (2009), chemical thinning application of apple trees is justified because of three reasons: chemical thinners reduce biennial production, reduce the cost of manual thininng, and their use affect the improvement of apple fruit quality. However, sometimes, except positive effetcs such as the increase of fruit mass and reduction of periodical productivity (Link, 1998), chemical fruit thinning can cause negative effects such as reduced yield (Duhanaj *et al.*, 2015; Elfving and Cline, 1993/a; 1993/b), fruit deformation at cv "Jonagored" (Rogers and Williams, 1977),

Fruitlets thinning is a very well-known agronomic practice which is being used from centuries to control the crop load and productivity of apple, pear, plum, grapevine, olive (Dennis, 2000; Wertheim, 2000) and several citrus cultivars (McArtney *et al.,* 2007) which have the tendency of biennial production. Crop regulation through blossom or fruitlets thinning can moderate alternate bearing, resulting in more consistent production and improved fruit size, as well as, increasing fruit quality, established different crop loads, from completely de-flowered to heavily fruiting, on 4-year-old 'Braeburn'/M.26 trees (Davis *et al.,* 2004). A low crop load decreased fruit yield, but improved fruit weight and fruit quality (Palmer *et al*., 1997).

Results from the recently published literature point to advantages of combining certain growth regulators and insecticides for apple fruit thinning (Jemrić *et al.,* 2003; Lakso *et al.,* 2000).

Combination of Carbaryl and 1-naphtaleneacetic acid has given good results in some years and climate conditions, but caused excessive thinning in some other years and climate conditions (Marini, 1996; Marini, 2000). Through winter pruning and green operations, such as branch top cutting, flower and fruit thinning, etc., fruit growers aims to ensure 30-40 healthy leaves for each fruit and try to avoid the high yield the first growing years of apple trees, which causes premature aging of apple trees (Davis *et al.,* 2004; Greene, 2002).

Marini (2004), Jemrić *et al.* (2003), etc., have reported that chemical fruit thinning had affected the year-by-year yield of Golden Delicious apple cultivar, reducing the genetic tendency for biennial yield. The aim of our study was to determine the effect of hand and chemical thinning (Carbaryl 1000 ppm + NAA 40 ppm) on the crop load and yield of "Jonagored" apple cultivar, trained on slender spindle and improved pyramidal systems.

Materials and Methods

Orchard placement

Study was carried out in 2013-2015 in Skivjan, Municipality of Gjakova, Kosovo, a very known area for apple orchards development. "Jonagored" apple orchard was planted in November 2006, with saplings grafted on M-9 rootstock, planted 3.8 m between rows and 1.8 m within a row (1462 apple trees ha^{-1}).

Rows orientation was North-South. Orchard was constructed in a hill 400 elevation. Eight years apple trees were healthy and with the same vegetative growth and development. "Jonagored" apple cultivar is one of the most widely planted cultivar in Gjakova's region, as well as in Albanian and Kosovo's orchards. Apple trees were trained on slender spindle, with hanged shoots, and improved pyramidal shapes, for better

use of the solar energy. Space between rows was grassed with tapecant plants and all cultural other cultural practices were applied regularly, as in common apple orchards.

Apple fruit thinning methods

The main objective of the study was to determine the effect of hand and chemical thinning (Carbaryl 1000 ppm + NAA 40 ppm) on the crop load and yield of "Jonagored" apple cultivar, trained on slender spindle and improved pyramidal shapes.

Apple fruit thinning was applied 15 days after bloom, when the fruitlets equatorial diameter was 10-12 mm. There were tested two thinning methods (two variants):

- V1 - hand thinning (mechanical thinning), leaving 1 fruit per cluster
- V2 - chemical thinning, using Carbaryl 1000 ppm + NAA 40 ppm, with a spraying volume of 1200 L per ha.

There were used two variants and two replications, with a variant size of 10 apple trees per replication. There were used 40 apple trees for each trained shape under study. Fruits were harvested at the same date for all variants during the three years of study. Harvest date has been determined according to the standard methods. The yield and the volume of crop load were measured for 4 randomly chosen apple trees of each treatment and replication. The combination of studied factors (fruitlets thinning and training system) was as in table 1.

Table 1. Combiantion of studied factors

Treatments	Combination of the studied factors
$A_1 B_1$	Hand thinning - slender spindle shape
$A_1 B_2$	Hand thinning - improved pyramidal shapes
$A_2 B_1$	Chemical thinning / slender spindle shape
$A_2 B_2$	Chemical thinning / improved pyramidal shapes

Measurements

For all apple trees of each treatment and replication were measured and calculated:

- Yield (Y) (kg per apple tree) at the harvest time
- Tree height (H) (m), measured from the bottom part of the crop load (the first shoots bifurcation) up to the top, (measured and calculated before winter prunnig)
- Mean diameter (D) and mean radius (R and r) (m) of the crop load measured and calculated before winter prunning
- Mean volume of the crop load (V) (m^3) – measured and calculated before winter prunnig

The volume of crop load of the slender spindle shape apples (V1) was calculated using the formula (1):

$$V_1 = \frac{1}{3} (R^2 \times \pi \times H) \quad (1)$$, where:

V1 = the volume of the crop load

R = radius of the circle of the crop load

H = from the bottom part of the crop load up to the top,

while the volume of crop load of the improved pyramidal shapes apples (V2) was calculated using the formula (2):

$$V_2 = \frac{1}{3} (R + r)^2 \times \pi \times H \qquad (2), \text{ where:}$$

V_2 = the volume of the crop load
R = radius of the circle at the bottom of the crop load
r = radius of the circle at the upper part of the crop load.
There were calculated mean values of each apple tree, each treatment and each training system.

Data analysis. The obtained data (differences between treatments (fruitlests thinning methods) and relationship between the studied indicators (yield and volume of crop load) and fruitlets thinning methods) were subject of descriptive and statistical analysis (ANOVA: Two-Factors Without Replication) ($\alpha = 0.05$) (Lekaj *et al.*, 2014).

Results and discussion

Effects of thinning methods on fruit yield and the volume of crop load of "Jonagored" apple cultivar were observed for two training systems, slender spindle and improved pyramidal shape. Observed results showed that the fruitlets thinning method (hand or chemical) has significantly affected both measured indicators on both training systems. The yield and the volume of crop load were measured for 4 randomly chosen apple trees of each treatment and replication.

The mean yield of the combination of the slender spindle shape apples and the hand thinning method was 33.25 kg per apple tree, while the mean volume of the crop load was 3.72 m^3 (Table 2).

The mean yield of the combination of the improved pyramidal shape apples and the hand thinning method was 38.12 kg per apple tree, while the mean volume of the crop load of the improved pyramidal shape apples was 11.12 m^3 or 3 times higher than the slender spindle shape apples, confirmed by the ratio V2/V1, where $V_2/V_1 = 11.12 / 3.72 = 2.989$. Apple trees of the improved pyramidal shape developed a large crop load and lead of higher apple yield (Table 2).

Table 2. Yield and volume of the crop load of hand thinning "Jonagored" apples, trained on slender spindle (SS) (A_1B_1) and improved pyramidal (IP) systems (A_1B_2) (mean values)

Replications	SS + hand thinning (A_1B_1)		IP + Hand thinning (A_1B_2)	
	Yield (kg per apple tree)	Volume of the crop load (m^3)	Yield (kg per apple tree)	Volume of the crop load (m^3)
P1	26	2.87	43	11.26
	34	3.00	36	8.37
	39	5.92	48	13.37
	23	2.22	31	9.51
P2	35	3.18	29	9.21

	42	6.26	34	12.14
	38	3.47	38	12.18
	29	2.85	46	12.90
Mean	**33.25**	**3.72**	**38.12**	**11.12**

The mean yield of the combination of the slender spindle shape apples and the chemical thinning method was 37 kg per apple tree, while the mean volume of the crop load was 4.226 m^3 (Table 3). Observed results showed that the yield of the combination of slender spindle shape apples and chemical thinning was 3.75 kg per apple tree or 11.28% higher compare to the combination of slender spindle shape apples and hand thinning, while the volume of the crop load of the combination of slender spindle shape apples and chemical thinning was 0.44 m^3 per apple tree or 11.64% higher compare to the combination of the slender spindle shape apples and hand thinning. The mean yield of the combination of the improved pyramidal shape apples and chemical thinning method was 43 kg per apple tree, while the mean volume of the crop load of the improved pyramidal shape apples was 12.74 m^3 or 3.01 times higher than the slender spindle shape apples, confirmed by the ratio V2/V1, where $V_2/V_1 = 12.74 / 4.22 = 3.01$. (Table 3).
Observed results showed that the yield of the combination of the improved pyramidal shape apples and chemical thinning was 4.88 kg per apple tree or 12.8% higher compare to the combination of improved pyramidal shapes apples and hand thinning, while the volume of the crop load of the combination of the improved pyramidal shape apples and chemical thinning was 1.62 m^3 per apple tree or 14.56% higher compare to the combination of improved pyramidal shape apples and hand thinning (Table 2 and 3).

Table 3. Yield and volume of the crop load of chemical thinning "Jonagored" apples, trained on slender spindle (SS) (A_2B_1) and improved pyramidal (IP) systems (A_2B_2) (mean values)

Replications	SS + hand thinning (A_2B_1)		IP + Hand thinning (A_2B_2)	
	Yield (kg per apple tree)	Volume of the crop load (m^3)	Yield (kg per apple tree)	Volume of the crop load (m^3)
P1	28	4.48	47	12.10
	37	3.98	38	13.77
	38	4.64	49	18.40
	41	5.19	46	14.16
P2	43	5.39	39	13.97
	38	3.51	37	11.27
	37	2.96	43	10.04
	34	3.66	45	8.23
Mean	**37**	**4.226**	**43**	**12.74**

Chemical frutilets thinning has significantly affected – increased the yield and the volume of crop load on both training systems because the phytophormone NAA and Carbaryl, except their effect on fruitlets thinning, affect the raise of the size of the shoots, leaves and fruit(lets) cells (Stopar *et al.*, 1997). Results of ANOVA showed that between

fruitlets thinning method and the yield and the volume of the crop load existed a significant relationship. Effects of the fruitlets thinning method and the yield and the volume of the crop load of "Jonagored" apple cultivar was statistically confirmed by statistical indicators values ($F = 12.17216 > F_{-crit} = 3.738892$ and P-value = 0.00044 < α = 0.05). There were not statistically confirmed differences between training systems for the same thinning method (Table 4).

Table 4. ANOVA-test for testifying the effects of thinning method on apple fruit yield and the volume of cropa load of "Jonagored" apple cultivar, trained on slender spindle and improved pyramidal systems ($p \leq 0.05$)

Source of variation	*SS*	*df*	*F*	*P-value*	*F-crit*
Rows (training systems)	172.2917	7	0.76137	0.06277	2.764199
Columns (thinning methods)	162.75	2	**12.17216**	**0.00044**	**3.738892**

Conclusions

Obtained results showed that fruit thinning method significantly affects the apple fruit yield and the volume of the crop load of "Jonagored" apple cultivar under climatic conditions of Skivjan, Gjakova, Kosovo. Chemically thinned apple trees, using Carbaryl 1000 ppm + NAA 40 ppm, showed higher fruit yield (3.75 kg or 11.28% and 4.88 kg or 12.8%, for chemically thinned of slender spindle and improved pyramidal systems, respectively).

Chemically thinned apple trees showed higher volume of the crop load on both training systems, as well. The volume of the crop load was increased by 0.44 m^3 or 11.64% and 1.62 m^3 or 14.56%, for chemically thinned of slender spindle and improved pyramidal systems, respectively.

Differences between fruit thinning methods for fruit quality indicators were statistically confirmed by ANOVA-test (F > F-crit and P-value < α = 0.05). Results confirmed that between fruitlets thinning method and the yield and the volume of the crop load existed a significant relationship.

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