The Influence of Thinning Agent on Base of 6-BA and NAA on Productivity and Fruit Quality of „Gala Must” Variety

Ananie PESTEANU^{1*)}

¹⁾ Faculty of Horticulture. State Agrarian University of Moldova, Republic of Moldova.

^{*)}Corresponding author, e-mail: a.pesteanu@uasm.md

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ABSTRACT

Chemical thinning of pome fruits 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. To evaluate the influence of thinning agent on base of 6-benzyladenine (6-BA) and naphthalene acetic acid (NAA) in reducing fruit set and quality in Gala Must apple trees. The experimental plot was founded in 2006 with trees of „knip boom” canopy type. The study subject of the experience was Gala Must apple variety grafted on M 9. The trees were trained as slender spindles. The distance of plantation is 3.5 x 1.2 m. The tested combination was 6-BA and NAA. The preparation was sprayed on the trees either one time, when the king fruit diameter was 10-15 mm. The research was conducted during the period of 2011 year. During the research, it was studied the number of blossom clusters before thinning degree, fruit at harvest time, yield, mean fruit weight, average fruit diameter, size classes based on their diameter and the number of pygmy fruits. It was established that, the good effect of thinning was noticed after single application of 100 ppm 6-BA + NAA 10 ppm. The combined treatment with 6-BA 100 ppm + NAA 10 ppm has a significant effect on yield, mean fruit weight and positively influenced fruit size, the distribution of apples in size classes.

Keywords: *apple, 6-BA and NAA, size classes, thinning, yield.*

INTRODUCTION

In recent years ‘Gala Must’ is one of the most important cultivars grown in Republic of Moldova. It is also one of the most widely accepted apples on the world market. Gala-derived cultivars typically produce more flowers and fruit than are needed to produce a full crop of marketable fruit (Basak, 2006; Bregoli *et al.*; 2007; Costa *et al.*, 2001; Stopar, 2002).

Hand thinning of the apple trees can be very accurate, but it is extremely expensive, and requires skilled labour inputs (Costa *et al.*, 2001). Heavy crop loads inhibit the ability of the tree to develop blossom buds for the following year, resulting in biennial bearing (Greene, 2002; Pesteanu, 2013; Tromp, 2000; Wertheim, 2000).

Gala cultivars have the high fertility and the extended bloom period. Therefore, this cultivars should be first thinned chemically, and only then by hand if needed (Basak, 2006; Costa *et al.*, 2001).

Chemical thinning with bioregulators decreases fruit set, increases average fruit weight of different apple cultivars and provides a good yield potential for the following vegetation (Basak, 2004; Greene, 2002; Petrcek and Silverman, 2003; Robinson, 2006; Stern *et al.*, 2006; Stopar, 2000).

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 thinning. Some of the fruit thinners can reduce fruit quality.

In addition, their effects may change depend on weather temperature in application time (Basak, 2004; Greene, *et al.*, 1990; Robinson *et al.*, 1998; Robinson and Lakso, 2000; Wertheim, 1997).

1-naphthaleneacetic acid (NAA) is an old thinning compound which is based on its hormonal action as a synthetic auxin (Sebek, 2014; Stopar, 2002). The mechanism of action of NAA is based on the stimulation of ethylene synthesis taking place in fruitlet tissue. It has also been ascertained that the natural drop of fruitlets is always connected with an increase in ethylene synthesis and evolution (Dennis, 2000). The effectiveness of fruitlet thinning with NAA is often unsatisfactory. The efficacy of the treatment depends on the weather which affects the intensity of the agent penetrating into leaf tissue (Basak, 2004). This can influence the intensity of ethylene synthesis and evolution and ultimately determine the effectiveness of the treatment. The most effective time to apply NAA as a chemical thinner is when fruit diameter is 7 to 9 mm or 11 to 13 mm (Greene, 2002; Pesteanu, 2013;).

Synthetic cytokinin 6-benzyladenine (BA) has been found to be a good thinning agent. BA thins fruitlets best at 10 mm fruitlet diameter and has a positive influence on return bloom (Robinson *et al.*, 1998; Greene, 1993). The advantage of BA as a synthetic cytokinin is its influence on hastened cell division so that the fruit enlargement should be greater than we could expect from its thinning action (Greene, 1993; Stopar and Zadavec, 2001).

The combination spraying of BA and NAA is sometimes recommended to get a stronger thinning response or to use lower rates of each thinner (Robinson *et al.*, 1998; Sebek, 2014). The aim of this study was to examine the efficacy of BA and NAA combination for the Gala Must cultivar in climatic condition of Republic Moldova.

MATERIALS AND METHODS

The research was conducted during the period of 2011 year in the superintensive apple tree orchard, growing at a village Sirota form district Orhei in the autumn of 2006 year at the Ltd. „Dacfruct” with trees of a „knip boom” canopy type.

The study subject of the experience was Gala Must apple variety grafted on M 9 weak vigour rootstock. The trees were trained as slender spindles. The distance of plantation is 3.5 x 1.2 m.

To optimize the fruit load of the apple trees were experimented the following variants of treatment:

1. Control – no treatment;
2. BA 100 ppm + NAA 10 ppm;
3. BA 140 ppm + NAA 14 ppm.

The treatments were carried out when the central fruit on the tree reached a value of fruit diameter ranging from 10 mm to 15 mm.

The soil was maintained with grass on intervals between rows and herbicided field between trees on row with a width of 1,2 m. It was used the drip irrigation system.

The plots placement was made in blocks, each variant having three repetitions and each one repetition consisted of 7 trees. At the boundaries between the plots and the experimental repetitions was left per 1 untreated tree to avoid duplication of some control variants or repetitions on making the treatments.

On experimental section in accordance with the experiences scheme, in the second variant was performed only one spray (5/23/11) with BA 100 ppm + NAA 10 ppm when the central fruit size diameter is 10-15 mm. In the third variant was also performed a single treatment with BA 140 ppm + NAA 14 ppm (5/23/11) when the central fruit size diameter is 10-15 mm. The treatment was performed by a portable watering tool during the hours without wind in the morning, at a temperature of +18°C, with tendency of temperature growth.

The amount of solution to a tree was 0.4 to 0.5 liters, based on the number of trees per unit area and the amount of water recommended by the 1000 l/ha. For a more positive grip of the solution with a leaf surface was added Silwet L77 from the ratio of 1 ml to 10 liters of water.

The effects on the fruit set, the yield, fruit quality at harvest and subsequent blooming were recorded and evaluated according to the following measurements: the number of inflorescences and the number of fruitlets on each tree; the fruit yield produced by each tree, and, for 1 ha orchard of apples; weight of 1 apple; the share of fruits (in %) in size classes based on their diameter from 50 mm to 80 mm with the intervals of 5 mm and relative effectiveness of treatments.

Thus, we see that the weather conditions during the surveys differ as between them and to

the multiannual average, but it were typical for the area and conducive to grow apple fructification and BA + NAA treatment.

RESULTS AND DISCUSSIONS

Investigations made demonstrate that in the period of 2010 year the Gala Must apple trees had differentiated a sufficient amount of bud fruit, that after pruning during the resting period in the summer of 2011 have formed 160-168 inflorescences (Tab. 1). The given amount of inflorescences demonstrates that the fruit trees have an uniform development and there are no big differences between them. It is maintained a co-report between the growth and fructification and because of the plot uniformity can be made experiences to test the combination of thinning agent BA + NAA according to the present program.

The investigations made show that the thinning agent on base of BA + NAA in the period when central fruit dimension was 10-15 cm in diameter had an influence on physiological fruit fall. In the control variant without thinning, the number of inflorescences was about 104 pcs/tree, or 63.8% of their total number. In variants 2 and 3, where is tested the thinning agent BA + NAA, the number of flowers was about 51-56 piece/tree, diminished from 1.86 to 2.04 times compared with control variant.

Studying the number of inflorescences formed at the variants with BA + NAA treatment, it is registered that the largest weight of flowers formed is in case is used the combination of BA 100 ppm + NAA 10 ppm - 56 pcs/tree. If to increase the dose to BA 140 ppm + NAA 14 ppm, then the total number of inflorescences was about 51 pcs/tree.

It is known that production quality is higher when in a single inflorescence is developing in the growing fruit. The investigations show that the most rational location of fruit was in the variant

where it was tested the combination of BA 100 ppm + NAA 10 ppm. In this case 83.9% from fruits are situated by one in an inflorescence, 12.5 % - by two, and 3.6 – by three. When increasing the dose to BA 140 ppm + NAA 14 ppm, it increases also the weight of fruits from 2 to 3 pieces in inflorescence diminishing to that with a single one.

In control variant 55.7% of the fruit number are placed by one in inflorescence, 34.6% - by two, 8.6% - by three and 1.1% - four.

Therefore, it was established that the combined application of BA + NAA influenced on the number 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.

Fruit production is a final index that is in a close connection to all the agro-technical procedures that are done in the orchard and are greatly different in comparison with the recommended dose of the growth regulator.

Apple tree treatments with BA + NAA combination had an influence on the number of fruits per tree according to the variant taken into the study (Tab. 2). The greatest quantity of fruits is registered at the control variant where it was made no treatment - 161 pcs/tree. Then in a descendant order is situated the variant BA 100 ppm + NAA 10 ppm - 69 pcs/tree and the variant BA 140 ppm + NAA 14 ppm - 68 pcs/tree, from which 8 are of „pygma” type. This demonstrates that the higher quantity of BA does not permit the split of cells in the fruit and their weight increase.

The study on fruit number per 100 inflorescences demonstrates an identical rule with the previously described one, constituting, corespondingly, 98, 41 and 38 pcs/100 inflorescences.

Tab. 1 Total inflorescences number (TIN), formed (FIN) in Gala Must apple tree variety canopy and the fruit weight in an inflorescence

Variants of treatment	TIN, pcs/tree	FIN, pcs/tree	Fruit weight in an inflorescence, %			
			1 pc.	2 pcs.	3 pcs.	>4 pcs.
Control	163	104	55.7	34.6	8.6	1.1
BA 100 ppm + NAA 10 ppm	168	56	83.9	12.5	3.6	-
BA 140 ppm + NAA 14 ppm	160	51	72.5	23.5	4.0	-

Tab. 2 Influence of BA + NAA combination on Gala Must apple tree production and quality parameters on harvest

Variants of treatment	Fruit number, pcs		Fruit production			Average weight, g	Average diameter, mm
	tree	100 inflores.	kg/cm ² TTS	kg/tree	t/ha		
Control	161	98	1.20	12.80	30.46	79.5	56.0
BA 100 ppm + NAA 10 ppm	69	41	1.02	9.58	22.80	138.8	68.0
BA 140 ppm + NAA 14 ppm	60/8*	38	0.64	7.21	17.16	120.1	62.2
LSD 5%	7.52	-	-	0.68	1.62	0.96	-

* -number of small fruit called „pygma”

Because, the smallest number of fruit per a tree and for 100 inflorescences was registered in the control variant a higher production per plant and surface unit was obtained in the same variant constituting, respectively, 12.80 kg/tree and 30.46 t/ha. A yield diminishment was registered in the variant BA 100 ppm + NAA 10 ppm, where the fruit production constituted 9.58 kg/tree and 22.80 t/ha. In case of applying the treatment with BA 140 ppm + NAA 14 ppm, it is registered an essential decrease of fruit production to 7.21 kg/tree, which is statistically demonstrated and decrease with 13.30 t/ha in comparison with the control variant.

Statistic processing data demonstrate us that a different statistic exists in all cases between the variants taken into the study.

Trunk transversal surface (TTS) is an index that permanently plantation productivity settlement. The investigations made demonstrates that the highest fruit productivity per 1 cm² TTS was registered in the control variant – 1.20 kg, where the fruit trees were not exposed to the process of thinning. There were obtained the highest values in the variant BA 100 ppm + NAA 10 ppm, where the fruit production constituted 1.02 kg/cm² TTS, or was registered a decrease of 15.0% in comparison with the variant control. With the decrease the dose to BA 140 ppm + NAA 14 ppm, fruit production diminishes with 87.5% in comparison with the control variant constituting 0.64 kg/cm² TTS.

Fruit quality it means a fruit average weight and diameter. Investigations made demonstrate that combination of BA + NAA as a preparation for

fruit chemical thinning had a great influence on production quality. If in the control variant, where there was made no chemical thinning, the average weight per a Gala Must apple fruit constituted 79.5 g, then the variants where is tested combination of BA + NAA, increased to 120.1-138.8 g. Studying the influence of thinning agent of fruit average weight registering higher values than the case when it made used treatment with BA 100 ppm + NAA 10 ppm – 138.8 g. With increase dose of thinning agent (BA 140 ppm + NAA 14 ppm) the average weight per a fruit diminishes with 18.7 g in comparison with the previous variant.

Fruit average diameter is an indicator with a direct tangency on average weight of obtained production. The lowest average diameter was registered in the control variant – 56.0 mm, where the trees were no thinning. Thus, in growth was placed the variant BA 140 ppm + NAA 14 ppm – 62.2 mm and variant BA 100 ppm + NAA 10 ppm – 68.0 mm.

The obtained results demonstrates that the highest fruit production was registered in the control variant, but the production quality is poor. 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 „pygma” fruit type appearance, diminishing the fruit number per a tree, average weight and diameter decreases, finally influencing the fruit production quantity and quality.

The investigations made demonstrates us that there is a proportional ratio between the fruit weight depending on the diameter and the experiences variant. As the number of fruits in crown is higher than the fruit weight with a small diameter increases and vice versa.

The study was not based only on knowing the average diameter of fruit, but knowing also the repartition of fruit per diameter from 5 to 5 mm in conformity with the experiences' variants.

Table 3 data demonstrates that in the control variant was produced an inferior net quality production. The highest weight (39.6%) is in the class with a lower diameter of 55 mm, 46.9% with a diameter of 56-60 mm and only 13.5% have a diameter of 61-65 mm. Thus, extra category and category I fruit in the control variant, without thinning, do not exist.

Continuing to study the influence of growth regulator on fruit quality, we register a more rational redistribution according to the trade standards in the variaant BA 100 ppm + NAA 10 ppm. In the given variant the fruit weight with a smaller diameter of 65 mm constituted 22.8%. In category I, the fruit with a diameter of 66-70 mm constituted 36.1%, but at the extra category is 41.1% from fruits. Thus, extra category and category I fruit weight constituted 77.2%.

In case when treating with BA 140 ppm + NAA 14 ppm we register an increase of fruit weight in the class with a diameter of <55-65 mm (56.2%) and a decrease of fruit quantity that is attributed to the diameter 66-75 mm (35.2%). Extra category and category I fruit weight constitutes 43.8%, or a decrease with 33.4% in comparisson with the variant BA 100 ppm + NAA 10 ppm.

Diameter index (R) constitutes the ratio of yield total quantity and quantity with a diameter less than 70 mm. The investigations made (Tab. 4) demonstrates that in the control variant the total fruit production per tree with a diameter lower than 70 mm is identical. As a result, diameter index, production and global indices is equal with 1.0.

When the amount of fruits withg the diameter lower than 70 mm decreases, the diameter index increase in fields treats with BA 100 ppm + NAA 10 ppm is 1.69 and when we using BA 140 ppm + NAA 14 ppm we notice higher values than in control variant, but with 25.2% lower than in variant 2.

To have higher production values index it is necessary that fruit production in the variants with treatments to be bigger than in the control variant. Investigations made demonstrate that a lower production index actions in case of treating with BA 140 ppm + NAA 14 ppm – 0.56, then, in

Tab. 3 Influence of BA + NAA combination on redistribution of fruit according to their diameter at Gala Must apple tree variety

Variants of treatment	Fruit weight (%) in accordance to their diameter (mm)					
	<55	56-60	61-65	66-70	71-75	76-80
Control	39.6	46.9	13.5	-	-	-
BA 100 ppm + NAA 10 ppm	-	5.0	17.8	36.1	32.2	8.9
BA 140 ppm + NAA 14 ppm	9.5	17.6	29.1	17.9	17.3	8.6

Tab. 4 Treatment relative efficiency for chemical thinning with BA + NAA combination in Gala Must variety plantation

Variants of treatment	Fruit production, kg/tree			Index	
	total	cu $\varnothing$ < 70 mm	diameter (R)	production (P)	global (G)
Control	12.80	12.80	1.0	1.0	1.0
BA 100 ppm + NAA 10 ppm	9.58	5.65	1.69	0.75	1.27
BA 140 ppm + NAA 14 ppm	7.21	5.35	1.35	0.56	0.76

an ascendant order, is placed the variant BA 100 ppm + NAA 10 ppm – 0.75, and the control variant, without thinning – 1.0.

The global index (G) constitutes the product of production diameter index and production index. The lowest values of global index are registered in the variant BA 140 ppm + NAA 14 ppm – 0.76 and control variant (1.0). In the variant of treating with BA 100 ppm + NAA 10 ppm, we register the highest global index – 1.27.

The researches made demonstrates that the highest values of real efficiency (diameter and global index) are registered in the variant with use combined application where the active substance of the product was BA 100 ppm + NAA 10 ppm.

CONCLUSION

It was observed that inadequate thinning influenced on fruit weight in inflorescence, number of fruits on tree, fruit production, average weight and average diameter, fruit redistribution according to their diameter and on the relative effectiveness of treatments.

It was demonstrated that combination of BA and NAA can be active as a thinner for the 'Gala Must' cultivar, when the sizes of king fruit diameter was from 10 mm to 15 mm.

Based on obtained experimental results the combined application where the active substance of the product was BA 100 ppm + NAA 10 ppm may be included in the system of chemical thinning to optimize the apple fruit load on 'Gala Must' cultivar.

The treatment with BA 140 ppm + NAA 14 ppm caused a decrease in average fruit, weight and appearance of fruits of „pygma” type.

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