

Effect of Application with Gibberellin GA₄₊₇ on Russetting of 'Golden Delicious' Apples

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Abstract

Worldwide, the presence of russet on 'Golden Delicious' apples has been a concern to producers and marketers of fresh fruit for a long time due to the fact that it decreases the smoothness, performs an uniform finish of the fruit and results in economic loss thru quality reduction. Apple cultivars present different degrees of susceptibility to russetting, and fruits in early stages of development are more susceptible than those in later stages. Under orchard conditions, russetting is avoided. For sensitive cultivars the aspect of peel is improved by applying gibberellin GA₄₊₇. The study subject of the experience was 'Golden Delicious' 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 gibberellic acid was GA₄₊₇ (Gerlagib LG). To study russetting of the apple fruits were experimented the following variants of treatment: 1. Control – no treatment; 2. GA₄₊₇ - 4 mg L⁻¹; 3. GA₄₊₇ - 5 mg L⁻¹. Trees were sprayed 4 times. The experiment was conducted in the year 2013. During the research, we studied the amount and average of fruits, tree production, firmness of fruits, and hydrolysis index. Russetting of fruit was estimated at harvest using a grading scale (S. J. Wertheim). It was established that, gibberellic acid GA₄₊₇ may be included in prevention system of apple fruits russetting with a dose of 5 mgL⁻¹, applied up to 4 times by treatment. First treatment should be performed starting at the beginning of petal fall stage, and the next 3 treatments 7-10 days after previous.

Keywords: Apple, GA₄₊₇ russetting, shape index, yield.

INTRODUCTION

Russetting is an important peel defect for many apples varieties due to the fact that their market value is reduced (Faust and Shear 1972; Wertheim 1982).

Apple cultivars differ in their susceptibility to russetting, fruits in early stages of development are more susceptible than those of later stages (Faust and Shear, 1972; Knoche *et al.*, 2011; Skene, 1982).

The external aspect produced by of russetting on the skin of apple fruits belonging to 'Golden Delicious' group, is the result of an interaction between epidermal structure which can be more or less sensitive to disturbances occurring in fruits, therefore predisposition is caused by a variety of environmental factors, such as: high

relative humidity, periods of rainfall (Creasy, 1980; Knoche *et al.*, 2011), low temperature during night or agrochemicals (Hatch, 1975; Taylor, 1975).

More researchs confirmed that the period of maximum sensitivity to russetting occurrence is considered between the second and fourth weeks after flowering, when the fruit diameter is between 15 to 30 mm (Knoche *et al.*, 2011; Wertheim 1982).

The methods that reduce or eliminate the formation of russetting focuses on the use of growth regulators and primarily those based on gibberellins acid GA₄₊₇ (Curry, 2012; Elfving and Allen, 1987; Greene, 1993; Looney *et al.*, 1992; Meador and Taylor, 1987; Wertheim, 1982).

The scientific news of the obtained results is that for the first time in Republic Moldova, the

treatment with GA₄₊₇ is recommend in fruit tree plantations prevention of russeting on 'Golden Delicious' apple variety.

MATERIALS AND METHODS

The research was conducted during 2013 year in apple orchard founded in 2006 year in Sirota village, district Orhei, in the company 'Dacfruct' Ltd with tree crown like "knip boom".

The subject of the experience was 'Golden Delicious' apple variety grafted on M9 rootstock. The trees were as slender spindle. The distance plantation is 3.5 x 1.2 m.

To study russeting of the apple fruits were experimented the following variants of treatment:

1. Control – without chemical treatments;
2. Gibberellin GA₄₊₇ - 4 mg L⁻¹;
3. Gibberellin GA₄₊₇ - 5 mg L⁻¹.

In variants 2 and 3, the first treatment was carried out at the end of flourish period 04/05/2013 and for following three treatments at 7-10 days after the previous one which means, the second at 13/05/2013, the third at 21/05/2013, and the fourth on 30.05 2013.

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 per tree was 0.4 to 0.5 liters, based on the number of trees per unit area and the amount of water recommended for 1000 l/ha.

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 repetition consisted of 7 trees. At the boundaries between the plots and the experimental repetitions was left 1 untreated tree in order to avoid duplication of some control variants or of repetitions while making the treatments.

The records for determining flowering rank were set during the period from pink button stage to share of inflorescences after the fall in June. The index form is the ratio of height fruit shape (H) and the diameter of the equatorial zone (D). The index form was estimated on 30 fruit from the tree at harvest time.

The amount of fruit, average weight of a fruit, tree production per surface and per unit were established during harvest. The results were compared to control version.

The evaluation was performed using apple firmness penetrometer FT 327, which secures ingress resistance of pulp on a piston area of 1 cm². Was conducted 10 assessments of firmness, being recorded media.

Hydrolysis index was established using iodine test. The fruits were compared with the diagram 10 drawn gradation conversion of starch elaborated by Ctifl collaborators (France).

Russeting of fruits was estimated at harvest time as described by S. J Wertheim (1982), where for 'Golden Delicious' variety was used gradual scale from 1 to 4. The first class is assigned to the fruits totally free of russet; 2- covered with russet up to 20% of the surface of the fruit; 3 - covered with russet up to 50% of the surface of the fruit; 4 - covered with a russet of more than 50% of the fruit surface, plus some cracks. The russet was calculated as a percentage.

RESULTS AND DISCUSSIONS

The investigations conducted during the rest period demonstrate that in 2012, trees were differentiated enough from fruit buds, which were formed 187-195 flowering inflorescences (tab. 1). The amount of inflorescences obtained demonstrates that trees have a uniform development and fitted for the experiences on testing the gibberellin GA₄₊₇ under the current program.

In the control variant, the difference between the total amount and related inflorescences was manifest, being 187 and respectively 69 pcs/tree. This demonstrates that only 36.7% of the total bound inflorescences.

To prevent the fruit russeting in the second and third variant was performed treatment with gibberellin GA₄₊₇.

The result presented in table 1 clearly demonstrates that gibberellin GA₄₊₇ influences the amount of inflorescences found in the three crown. When using gibberellin GA₄₊₇ in concentration 4 mg L⁻¹, the number of inflorescences was 101 pcs/tree, recording an increase of 46.4% compared to the control variant. When dealing with gibberellin GA₄₊₇ in concentration of 5 mg L⁻¹, a slight increase in the quantity of inflorescences related, compared

with the previous version, constituting 102 pcs/tree was observed, and compared to the control variant, it increased by 47.8%.

The study on fruit weight in an inflorescence demonstrates that in the control variant, 44.9% of inflorescences were recorded with a fruit, two fruits 33.3% and the 21.8% fruit three.

During the research, a more rational location of fruits in the inflorescence was registered for treatment with gibberellin GA₄₊₇. While treating trees with gibberellin GA₄₊₇, we record inflorescences with a larger share of fruit, and a decreasing of those with 2 and 3 fruits.

When treating with gibberellin GA₄₊₇ in concentrations of 4 mg L⁻¹, the weight of one fruit in inflorescence was 81.2%, the two fruits - 14.9% and three fruits - 3.9%. When using concentration of 5 mg L⁻¹, it was recorded that the weight of inflorescences with a fruit is about the same level as in second variant, representing 82.4%, of the fruit by 2 - 15.7%, decreasing up to 1.9% inflorescences amount of 3 fruit.

The results have allowed establishing that treatments with gibberellin GA₄₊₇ in concentrations of 5 mg L⁻¹ had a positive influence on the amount of linked flowering in the trees crown. In addition,

it can be noticed an increase of sharing of one fruit in blossom, against those of 2 to 3 fruits compared to control variant.

The fruit production is the final index which indicates how the agro-technical measures were made in apple plantations variety 'Golden Delicious'.

The study on the use of growth regulators GA₄₊₇ has shown that its use influences the average weight of a fruit and of the entire production.

The largest amount of fruit (tab. 2) was obtained in the variant were trees were treated with gibberellin GA₄₊₇ in concentrations of 4 mg L⁻¹ on - 124 pcs/tree. In the control variant and when we use the growth regulators GA₄₊₇ in concentrations of 5 mg L⁻¹, recorded the same values, the fruit quantity was diminished to 122 pcs/tree.

The average weight of a fruit in studied variants go through some changes compared to control variant. The lowest average weight of a fruit that has been recorded in control variant was 164 g. When using growth regulators gibberellin GA₄₊₇ in concentrations of 4 mg L⁻¹, the average weight of a fruit was 178 grams, so an increase of 8.3% compared the control variant. When the

Tab. 1. The amount of total inflorescences (ATI), related (ARI) in the crown of apple trees of the variety 'Golden Delicious' fruits and share in an inflorescence

Nr. d/o	Variants	ATI, pcs /tree	ARI, pcs /tree	The share of fruits in a inflorescence, %		
				1 pc	2 pcs	3 pcs
1.	Control	187	69	44.9	33.3	21.8
2.	Gibberellin GA ₄₊₇ , - 4 mgL ⁻¹	193	101	81.2	14.9	3.9
3.	Gibberellin GA ₄₊₇ , - 5 mgL ⁻¹	195	102	82.4	15.7	1.9

Tab. 2. The influence of gibberellin GA₄₊₇ on fruit production on the apple trees of 'Golden Delicious' variety

Nr. d/o	Variants	Fruit quantity, pcs/tree	Average weight, g	Fruit production		In % compare with witness
				kg/tree	t/ha	
1.	Control	122	164	20.00	47.60	100.0
2.	Gibberellin GA ₄₊₇ , - 4 mgL ⁻¹	124	178	22.07	52.50	110.3
3.	Gibberellin GA ₄₊₇ , - 5 mgL ⁻¹	122	185	22.57	53.72	112.8
	LSD 5%	3.7	8.3	0.77	1.75	-

dose of the growth regulator GA_{4+7} was increased to 5 mg L^{-1} , the average weight of a fruit increased by 12.8% compared to the version control. This increase in the average weight is recorded due to the higher number of cells formed in fruits and their elongation under the influence of gibberellin GA_{4+7} , compared to the control variant, where these multiplier processes went normally without any influence.

Due to the fact that the lowest number of fruits per tree and lighter weight of a fruit was recorded in the control variant, also we record lower production per tree and per surface unit respectively being 20.00 kg/tree or 47.60 t/ha .

When using gibberellin GA_{4+7} in concentrations of 5 mg L^{-1} on the amount of fruits per tree, the results were the same as in the control variant, due to higher average fruit weight, it increased the production on a tree, respectively the productivity in a unit area and also, production data to a tree and a unit area recorded maximum values, representing 22.57 kg/tree and respectively 53.72 t/ha .

While using gibberellin GA_{4+7} in concentrations of 4 mg L^{-1} , the fruit production recorded lower values compared to variant 3, the quantity of fruits per tree was 22.07 kg , and at one hectare - 52, 50 t.

When studying the influence of treatment concentration (4 mg L^{-1} and 5 mg L^{-1}) of gibberellic acid on fruit production, it was registered a slight difference of 0.50 kg/tree respectively 1.22 t/ha , and 2.5%, that were unproven statistically.

The results of statistical investigation of fruits production show a significant difference between the variant 2, 3 and version control. For example, the difference between the production of fruits obtained in control and variant gibberellin GA_{4+7} in concentrations 4 mg L^{-1} that was 10.3%, while in the variant gibberellin GA_{4+7} in concentrations of 5 mg L^{-1} amount that increased to 12.8%.

The results demonstrated the highest fruit production was recorded in the treated variants with gibberellin GA_{4+7} where the fruit harvest it was lower.

The shape of fruit is a hereditary and specific characteristic, which is expressed in index form, calculated from height and diameter of apples.

The provided studies demonstrates that the rate of fruit shape can be influenced with the aid of growth regulators on the basis of gibberellic acid GA_{4+7} , which is characterized by stretching of fruit cells. Cell elongation allows fruit to influence index form.

Studying the fruit height, it shows that the lowest values were obtained in control variant - 71.5 mm (tab. 3). While studying the process of changing the height of 'Golden Delicious' fruits under the influence of gibberellin GA_{4+7} we observed an increase on fruit height. If, in control variant, fruit height was 71.5 mm , then the growth regulator GA_{4+7} treatments increased this index to $74.1 - 74.5 \text{ mm}$.

Comparing variants treated with gibberellin GA_{4+7} , it records, that in concentrations of 4 mg L^{-1} fruit height increased by 3.6% compared to control, constituting 74.1 mm . With increasing the dose of the growth regulator GA_{4+7} to 5 mg L^{-1} , the study index shows higher values by 4.2% compared to control variant, constituting 74.5 mm .

The diameter of a fruit in the studied variants underwent through some changes. The smallest diameter of a fruit has been recorded in control variant - 72.2 mm . When using gibberellin GA_{4+7} in concentrations 4 mg L^{-1} , the diameter of fruits was 73.4 mm , therefore an increase of 1.7% compared with the control variant. By increasing the dose of gibberellin GA_{4+7} to 5 mg L^{-1} , also increased the fruit diameter by 1.1%, compared to the control variant, but decreased it by 0.6% compared with the treatment in concentrations 4 mg L^{-1} .

Tab. 3. The influence of gibberellin GA_{4+7} on fruit shape index of apple variety 'Golden Delicious'

Nr. d/o	Variants	Fruit height, (H)	Fruit diameter, (D)	Form index (If)
1.	Control	71.5	72.2	0.99
2.	Gibberellin GA_{4+7} - 4 mgL^{-1}	74.1	73.4	1.01
3.	Gibberellin GA_{4+7} - 5 mgL^{-1}	74.5	73.0	1.02

This increase in the diameter is recorded due to the higher number of cells formed in fruits and their elongation under the influence of growth regulators GA₄₊₇.

Because the lowest height and diameter of fruit was recorded in the control variant, also the values form fruit index were lower. For control variant form index was 0.99.

When using growth regulators GA₄₊₇ in concentrations 4 mg L⁻¹ fruit height is increased more significantly in comparison with their diameter, increasing the index form to 1.01, therefore an increase of 2.2% compared to the control variant.

In the case where the treatment formulation was used in concentrations of 5 mg L⁻¹, fruit production shows higher values by 3.0%, compared to the control variant and by 1.0% compared with the variant GA₄₊₇ in concentrations of 4 mg L⁻¹.

When studying the influence of treatment with growth regulator GA₄₊₇, it shows higher values on the index form when used concentrations 5 mg L⁻¹.

It is very important that apples are harvested at the optimum moment. If apples are harvested prematurely, the losses can be about 10-15% of the harvest, because they have insufficient size and light weight. The fruits collected to late have low pulp firmness and are not resistant to manipulation.

The results of the table 4 prove that the apple pulp firmness at harvest time, on the studied variants, ranged from 7.5-7.8 kg/cm². This demonstrates the optimal firmness for harvesting 'Golden Delicious' variety for long-term storage.

While studying how to change the firmness of 'Golden Delicious' variety fruit under the influence of gibberellin GA₄₊₇, we observed that the regulator increased the firmness of the apples. If, in the case of control variant, firmness of the apples was 7.5

kg/cm², then the variants treated with gibberellin GA₄₊₇, this index increased and reached 7.6-7.8 parameters kg/cm².

By comparing the treated variants with gibberellin GA₄₊₇, it was recorded that on concentrations of 4 mg L⁻¹ increased the fruit firmness by 0.1 kg/cm², compared with the control variant, being 7.6 kg/cm². With increasing the concentrations of the gibberellic acid GA₄₊₇ to 5 mg L⁻¹ the studied index constitutes 7.8 kg/cm².

Studying the influence of the dose treatment on the fruit firmness index, it was recorded that the increase of the amount of growth regulator at concentrations of 4 mg L⁻¹ and 5 mg L⁻¹ increases the firmness of apples by 0.2 kg/cm².

The content soluble solid is a feature of the variety and after its value it can establish the optimal harvest time. As closer to harvest time, the intensity of accumulation of soluble dry substances decreases.

Investigations conducted demonstrate that the quantity of dry substances soluble on 'Golden Delicious' variety, in the studied variants varied from 11.8 to 12.1%.

The highest value of soluble dry substance was registered in version control without treatment - 12.1%. When treatment with gibberellin GA₄₊₇ was made, the index declined in the study from 11.8 to 12.0%. Therefore, treatment with gibberellin GA₄₊₇, somehow delays fruit maturation and reduces soluble solids content of fruit by 0,1 - 0,4% compared to the control variant.

In the process of fruit ripening, the starch of hydrolysis monosaccharide occurs, so their quantity decreases. The degree of starched hydrolysis can be determined by applying the test iodine. The cross-sectional coloration decreases in the fruit that contains less starches, which shows a progression in fruit ripening.

Tab. 4. The influence of gibberellin GA₄₊₇ on the index of fruit ripening on apple variety 'Golden Delicious'

Nr. d/o	Variants	Firmness, kg/cm ²	Soluble solids, %	Hydrolysis index (1-10)
1.	Control	7.5	12.1	5.1
2.	Gibberellin GA ₄₊₇ - 4 mgL ⁻¹	7.6	12.0	5.0
3.	Gibberellin GA ₄₊₇ - 5 mgL ⁻¹	7.8	11.8	4.9

Tab. 5. The influence of gibberellin GA₄₊₇ on fruit weight depending on the condition of russeting on apple variety 'Golden Delicious', %

Nr. d/o	Variants	Without russet	Up to 20%	Up to 50%	Unconditional fruits
1.	Control	15,4	37,7	30,5	16,4
2.	Gibberellin GA ₄₊₇ , - 4 mgL ⁻¹	61,1	24,3	14,6	-
3.	Gibberellin GA ₄₊₇ , - 5 mgL ⁻¹	74,3	19,7	6,0	-

The conducted investigations demonstrate that the rate of hydrolysis in studied variants varies from 4.9 to 5.1. The greatest number of hydrolysis (5.1) were recorded in control variant, where trees have not been subjected to treatment with growth regulators.

The treatment with gibberellin GA₄₊₇ influences the fruit ripening. In alternative, gibberellin GA₄₊₇ concentrations of 4 mg L⁻¹, hydrolysis index was 5.0 or lower by 0.1 compared to the control variant.

This demonstrates that depending on the hydrolysis index registered in control variant, and in treated variants with gibberellin GA₄₊₇, fruits can be harvested for long term storage in refrigerators.

The results of study (tab. 5) demonstrates that the percentage of apples without russeting in the studied variants is 15.4 to 74.3%. The lowest values obtained in control variant - 15.4%. When treating with gibberellic acid GA₄₊₇ it records increased share of apples without russeting. In variant gibberellin GA₄₊₇ concentrations 4 mg L⁻¹ the studied index was 61.1%, therefore an increase of 45.7% compared to the control variant. In variant gibberellin GA₄₊₇ with concentrations of 5 mg L⁻¹, the share of apples without russeting increased and reached maximum values of 74.3%.

Comparing variants treated with gibberellin GA₄₊₇, it was recorded that at concentrations of 5 mg L⁻¹, apples without russeting share increased by 13.2% compared variant gibberellin GA₄₊₇, concentrations 4 mg L⁻¹.

If up to 20% of the fruit is covered with russet, apples should be assigned to the first quality category. The largest share of apples russet was recorded in control, without treatment - 37.7%. When treatment was applied with gibberellin GA₄₊₇, the index declined in the study from 19.7 to 24.3%. Therefore, treatment with gibberellin GA₄₊₇ impose a more uniform development of the fruit cells, and so a smaller amount of cracks in

the epidermis affected by reducing the russeting surface of fruit. In variant gibberellin GA₄₊₇ with concentrations of 4 mg L⁻¹, the studied index showed values of 24.3%, or a 13.4% decrease compared to the control variant. In variant gibberellin GA₄₊₇ in concentrations of 5 mg L⁻¹, share apples with minimal russeting values reached 19.7%, or a decrease of 18.0% compared to the control.

The fruits that belonged to these were the surface was covered by russeting from 20% to 50% were attributed to second class quality. In control variant, the amount of apples with russet was 30.5%. The treatments with gibberellin GA₄₊₇ in concentrations of 4 mg L⁻¹, the index declined to 14.6%, and for the concentrations of 5 mg L⁻¹ to 6.0%. Unconditional fruits were recorded only in the control version, whose share was 16.4%

This study demonstrates that the most constant outcomes on quality index are recorded when treatment were made with gibberellin GA₄₊₇ in concentrations of 5 mg L⁻¹.

CONCLUSION

The gibberellin GA₄₊₇ influenced on apple variety 'Golden Delicious' the share of fruits in a inflorescence, fruit production, fruit shape index, index of fruit ripening and the percentage of apples without russeting.

The gibberellin GA₄₊₇ may be included in the system to prevent russeting on apple variety 'Golden Delicious', in concentrations of 5 mg L⁻¹, applied up to 4 times by sprinkling. First treatment performed at the end of flourish, and the next 3 treatments 7-10 days after previous.

REFERENCES

1. Creasy L L (1980). The correlation of weather parameters with russetof 'Golden Delicious' apples under orchard conditions. J. Amer. Soc.Hort. Sci. 105:735-738.

2. Curry E (2012). Increase in epidermal planar cell density accompanies decreased russetting of 'Golden Delicious' apples treated with gibberellin A₄₊₇. HortScience. 47 (2): 232-237.
3. Elfving DC Allen OB (1987). Effect of gibberellin A4+7 applications on Golden Delicious fruit russet. Crop Res. 27: 11-18.
4. Faust M , Shear CB (1972). Russetting of apples, an interpretive review. HortScience 7: 233- 235.
5. Greene DW (1993). Effects of GA4 and GA7 on flower bud formation and russet development on apple. J. Hort. Sci. 68: 171-176.
6. Hatch AH (1975). The influence of mineral nutrition and fungicides on russetting of 'Goldspur' apple fruit. J. Amer. Soc. Hort. Sci. 100: 52-55.
7. Knoche M, Khanal BP, Stopar M (2011). Russetting and microcracking of 'Golden Delicious' apple fruit concomitantly decline due to gibberellin A4+7 application. J. Amer. Soc. Hort. Sci. 136: 159-164.
8. Looney NE, Granger RL, Chu CL, McArtney SJ, Mander LN, Pharis RP(1992). Influences of gibberellins A4, A4+7, and A4+iso-A7 on apple fruit quality and tree productivity. I. Effects on fruit russet and tree yield components. J. Hort. Sci. 67:613-618.
9. Meador DB , Taylor BH (1987). Effect of early season foliar sprays of GA4+7 on russetting and return bloom of 'Golden Delicious' apple. HortScience 22:412-415.
10. Skene DS (1982). The development of russet, rough russet and cracks on the fruit of the apple Cox's Orange Pippin during the course of the season. HortScience. 57: 165-174.
11. Taylor BK (1975). Reduction of apple skin russetting by gibberellin A4+7. J. Hort. Sci. 50:169-172.
12. Wertheim SJ (1982). Fruit russetting in apple as affected by various gibberellins. J. Hort. Sci. 57:283-288.