

The impact of bioregulators and biostimulator on the fruit quality of sweet and sour cherries

Biserka Milić¹, Nenad Magazin¹, Zoran Keserović¹, Maja Milović¹, Jelena Kalajdžić¹, Stefan Gligorić¹, Jelena Savićević²

¹University of Novi Sad, Faculty of Agriculture, Trg Dositej Obradovića 8, 21000 Novi Sad, Republic of Serbia,

*E-mail: biserka.milic@polj.uns.ac.rs

²Dedovina d.o.o., Koštunići 280, 32300 Gornji Milanovac, Republic of Serbia

Received: 22 November 2024; Accepted: 10 April 2025

Abstract. Bioregulators and biostimulators play a significant role in enhancing fruit set, weight and firmness in different tree fruit species. The aim of this study was to examine the effects of the products based on gibberellic acid (GA), 6-benzyladenine (BA), and α -naphthaleneacetic acid (NAA) on fruit set and fruit quality in the sweet and sour cherry cultivars ‘Skeena’ and ‘Érdi Bőtermő’. For sweet cherries, the treatments involved ‘OroGibb’ (GA₃ 1.6 % + BA 1.6 % + B) and ‘GranPera’ (GA₃ 2% + P, K), at concentrations of 10 mg l⁻¹ and 20 mg l⁻¹ active ingredient (a.i.), applied at the flowering fading (BBCH 67) or when the fruit reached 60% of final size (BBCH 76). The following treatments were established: I (‘OroGibb’ at 10 mg l⁻¹ a.i., applied at BBCH 67 stage); II (‘OroGibb’ at 20 mg l⁻¹ a.i., applied at BBCH 67 stage); III (‘GranPera’ at 10 mg l⁻¹ a.i., applied at BBCH 67 stage); IV (‘GranPera’ at 10 mg l⁻¹ a.i., applied two times at BBCH 76 stage); V (‘GranPera’ at 20 mg l⁻¹ a.i., applied at BBCH 67 stage); VI (‘GranPera’ at 20 mg l⁻¹ a.i., applied two times at BBCH 76 stage). In addition to ‘OroGibb’ and ‘GranPera’, ‘FrutaFija’ (amino acids 4.5%; P₂O₅ 13%; K₂O 18%; B 0.5%; Fe 0.04%; Cu 0.01%) biostimulator was also used for sour cherry. The applied concentrations were 10 mg l⁻¹ and 20 mg l⁻¹ a.i., and time of application was at the end of flowering (BBCH 69) or/and when the fruit reached 60% of final size (BBCH 76). The following treatments were established: I (‘OroGibb’ at 10 mg l⁻¹ a.i., applied at BBCH 69 and BBCH 76 stages); II (‘OroGibb’ at 20 mg l⁻¹ a.i., applied at BBCH 69 and BBCH 76 stages); III (‘GranPera’ at 10 mg l⁻¹ a.i., applied at BBCH 69 and BBCH 76 stages); IV (‘GranPera’ at 20 mg l⁻¹ a.i., applied at BBCH 69 and BBCH 76 stages); V (‘FrutaFija’ at 20 mg l⁻¹ a.i., applied at BBCH 69 stage). Untreated trees of both fruit species were used as control. The highest fruit weight (11.6 g) and diameter (29.0 mm) of ‘Skeena’ were recorded in treatment VI. Applied treatments had no impact on fruit firmness, soluble solids content and acidity of ‘Skeena’ fruits. The highest fruit set of sour cherry cultivar ‘Érdi Bőtermő’ was recorded in the treatment I (27.4%), but only this treatment showed no significantly higher fruit weight and diameter compared to the control. Sour cherry fruits from treatment III exhibited significantly higher fruit firmness compared to the control, while the fruits from treatments I, II and III were characterized by a higher content of soluble solids and total acids.

Key words: stone fruit, GA₃, BA, NAA, fruit set, fruit weight, SSC, total acidity

Introduction

Sweet and sour cherry are very important stone fruit species in the Republic of Serbia, with production amounts of 15,522 tons and 145,143 tons, respectively (Statistical Office of the Republic of Serbia, 2023). Sweet cherries are primarily used for fresh consumption, while sour cherries, depending on the variety, can be grown for either fresh consumption or processing. For fruits intended for fresh consumption, key quality parameters for evaluation include mass, diameter, and fruit firmness, as these factors significantly impact their market value (Kantaroglu & Demirbaş, 2020).

Modern fruit growing use of bioregulators. In order to obtain fruit quality that meets market standards and ensures high prices, bioregulators have gained special attention among researchers and producers (Milić *et al.*, 2016; Canli *et al.*, 2015a; Abdel-Mohsen & Kamel, 2015; Milić *et al.*, 2018; Canli *et al.*, 2015b). The impact of gibberellic acid (GA_3) on fruit size, firmness, and chemical composition depends on several factors: the applied concentration (Correia *et al.*, 2019; Pehlivan *et al.*, 2012; Zhang & Whiting, 2011), the timing of application (Kappel & MacDonald, 2002; Basak *et al.*, 1998), the number of treatments during the growing season (Lenahan *et al.*, 2006), and the tested cherry cultivar (Kuhn *et al.*, 2021). Gibberellins promote cell division and elongation (Thakur, 2016), which results in larger fruit size. The effect of GA_3 on retaining fruit firmness is due to a reduction in the activity of pectin methylesterase and polygalacturonase, enzymes responsible for the breaking down of the cell wall (Choi *et al.*, 2002). The effect of 6-benzyladenine (BA) on fruit quality largely depends on the applied concentration and the cherry cultivar tested. When applied at a concentration of 15 ppm, BA does not affect fruit weight (Sabir *et al.*, 2021), while trees treated with BA at a concentration of 50 ppm produce significantly larger fruits compared to untreated ones (Zhang & Whiting, 2011). The increase in fruit size results from BA's effect on stimulating cell division within the fruit cortex (Milić *et al.*, 2016).

The effect of α -naphthaleneacetic acid (NAA) is observed in the increase in fruit weight and diameter (Zeman *et al.*, 2013), as well as in either an increase or

decrease in fruit firmness (Clayton-Cuch *et al.*, 2021). The impact of NAA on fruit weight and diameter can be explained by the role of auxins in stimulating carbohydrate translocation into the fruit and enhancing cell wall elasticity, which promotes cell enlargement, thereby increasing fruit weight, diameter, and yield (Arteca, 1996). The effect of NAA on fruit quality depends on the applied concentration, timing of application, and the tested cultivar (Zeman *et al.*, 2013; Clayton-Cuch *et al.*, 2021).

The aim of this study is to examine the effects of different application timings and rates of products based on gibberellic acid (GA_3), 6-benzyladenine (BA), and α -naphthaleneacetic acid (NAA) on fruit set and quality in the sweet cherry cultivar 'Skeena' and the sour cherry cultivar 'Érdi Bőtermő' at harvest time.

Materials and Methods

Plant material and experimental design. The research was conducted in 2024 and investigated the impact of bioregulators on the fruit quality of sweet and sour cherry. The sweet cherry orchard (cultivar 'Skeena' grafted onto the 'Gisela 6' rootstock) used in the experiment is located in Selenča (45°24'20"N; 19°17'32"E), and is owned by the company 'Ripe Fruit Farm' d.o.o. The orchard was established in 2011 with a planting distance of 4 m $\times$ 2 m (1,250 trees ha⁻¹). Experimental sour cherry orchard (cultivar 'Érdi Bőtermő' grafted onto the 'Gisela 5' rootstock), is located at the Experimental Field of the Faculty of Agriculture in Novi Sad, Rimski Šančevi (45°20'20.7"N; 19°50'18.8"E). This orchard was established in 2020 with a planting distance of 3.5 m $\times$ 1.5 m (1,904 trees ha⁻¹). Both experimental orchards were irrigated and maintained by grass cover in inter-row spaces, while row spaces were managed using herbicides. Standard agro-technical measures were regularly applied in the orchards. The sweet cherry experiment was designed as a completely randomized block design with 10 replications per treatment, where each treated tree represented one replication. Ten uniform untreated trees were also selected as controls. Concentrations and timings of chemicals applied are presented in Table 1.

Table 1. Concentrations and timings of chemicals applied to sweet cherry cultivar ‘Skeena’

Tabela 1. Koncentracije i vreme primene tretmana kod trešnje sorte Skina

Treatment <i>Tretman</i>	Compound name <i>Naziv</i>	Active ingredients <i>Aktivna materija</i>	Time of application <i>Vreme primene</i>	Concentration of a.i. <i>Koncentracija aktivne materije</i> (mg l ⁻¹)	Dose applied <i>Doza primene</i> (ml ha ⁻¹)
I	Oro Gibb	GA ₃ 1.6 % + BA 1.6 % + B	*BBCH 67	10	312.5
II	Oro Gibb	GA ₃ 1.6 % + BA 1.6 % + B	BBCH 67	20	325.0
III	Gran Pera	GA ₃ 2% + P, K	BBCH 67	10	250.0
IV	Gran Pera	GA ₃ 2% + P, K	BBCH 76	10 × 2	250.0
V	Gran Pera	GA ₃ 2% + P, K	BBCH 67	20	500.0
VI	Gran Pera	GA ₃ 2% + P, K	BBCH 76	20 × 2	500.0

*BBCH – Phenological growth stages of sweet sherry according to the BBCH scale Fadón et al. (2015); / *BBCH – fenološke faze rasta trešnje prema BBCH skali Fadón et al. (2015).*

The trees were sprayed using a backpack sprayer (STIHL SR-420), applying 500 l ha⁻¹, which corresponded to 4 l of water for 10 sweet cherry trees. Harvesting was conducted on June 4, and a random sample of 50 fruits was taken from each treatment and the untreated control.

The sour cherry experiment was designed as a completely randomized block design with seven replications per treatment, where one treated tree represented one replication. Seven uniform untreated trees were also selected as controls. Concentrations and timings of chemicals applied are presented in Table 2.

The trees were sprayed with a backpack sprayer (STIHL SR-420), applying 816 l ha⁻¹. Harvesting was

conducted on May 29, and a random sample of 100 fruits was taken from each treatment and the untreated control.

Measurements. On each sour cherry tree, one fruit-bearing branch was selected, and the number of flowers was counted to calculate the fruit set percentage. The fruit set percentage was determined by multiplying the total number of fruits counted on the marked branches before harvest by 100, then dividing it by the total number of flowers previously counted on the same branches.

After the harvest, the following fruit analyses were conducted in the Pomology laboratory at the Faculty of Agriculture in Novi Sad. Fruit weight was

Table 2. Concentrations and timings of chemicals applied to sour cherry cultivar ‘Érdi Bőtermő’

Tabela 2. Koncentracije i vreme primene tretmana kod višnje sorte Erdi botermo

Treatment <i>Tretman</i>	Compound name <i>Naziv</i>	Active ingredients <i>Aktivna materija</i>	Time of application <i>Vreme primene</i>	Concentration of a.i. <i>Koncentracija aktivne materije</i> (mg l ⁻¹)	Dose applied <i>Doza primene</i> (ml ha ⁻¹)
I	OroGibb	GA ₃ 1.6 % + BA 1.6 % + B	*BBCH 69 BBCH 76	10	544
II	OroGibb	GA ₃ 1.6 % + BA 1.6 % + B	BBCH 69 BBCH 76	20	1088
III	GranPera	GA ₃ 2% + P, K	BBCH 69 BBCH 76	10	476
IV	GranPera	GA ₃ 2% + P, K	BBCH 69 BBCH 76	20	952
V	FrutaFija	amino acids 4.5%; P ₂ O ₅ 13%; K ₂ O 18%; B 0.5%; Fe 0.04%; Cu 0.01%	BBCH 69	20	585

*BBCH – Phenological growth stages of sweet sherry according to the BBCH scale Fadón et al. (2015); / *BBCH – fenološke faze rasta trešnje prema BBCH skali Fadón et al. (2015).*

determined using a precision scale (Kern 572-35, Kern & Sohn, GmbH, Balingen, Germany) and expressed in grams (g). Fruit diameter and stem length (mm) were measured using a digital caliper (Mitutoyo, Tokyo; Japan). Soluble solids content (SSC) was measured with a digital refractometer (PAL-BX/ACID F5 ATAGO, Cat. No 7100, Japan) and expressed in Brix°. Total acids content (TA), expressed as a percentage (%), was determined by titrating filtered juice with 0.1 N NaOH until a stable pH value of 8.2 was reached, using phenolphthalein as an indicator (Chapon & Westercamp, 1996). Fruit firmness (kg cm^{-2}) was measured on 20 fruits per treatment using a texture analyzer with an 8 mm diameter probe (FTA-25, Güss System, RSA) (Kalajdžić *et al.*, 2019).

Statistical analysis. Statistical analysis of the data was performed using a one-way analysis of variance (ANOVA) method. The statistical significance of differences between the mean values of treatments was determined using Duncan's multiple range test, with a significance level of 0.05.

Results

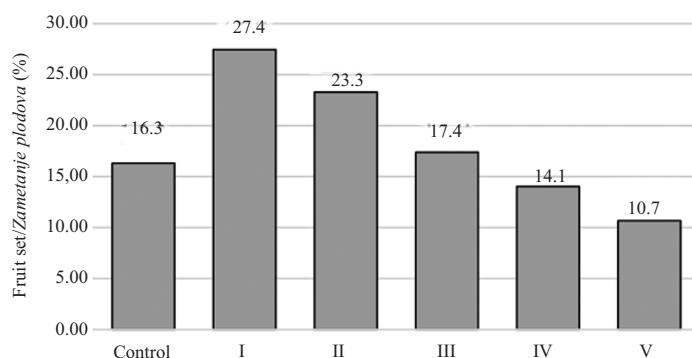
The fruit set is presented in Graph 1 as the ratio of the number of flowers to the number of fruits, which was 16.30% in the untreated control. In treatments IV and V, the fruit set was lower, while treatments with 'OroGibb' (treatments I and II) resulted in a higher fruit set compared to the control. The highest fruit set

was recorded in the treatment I, amounting to 27.4%.

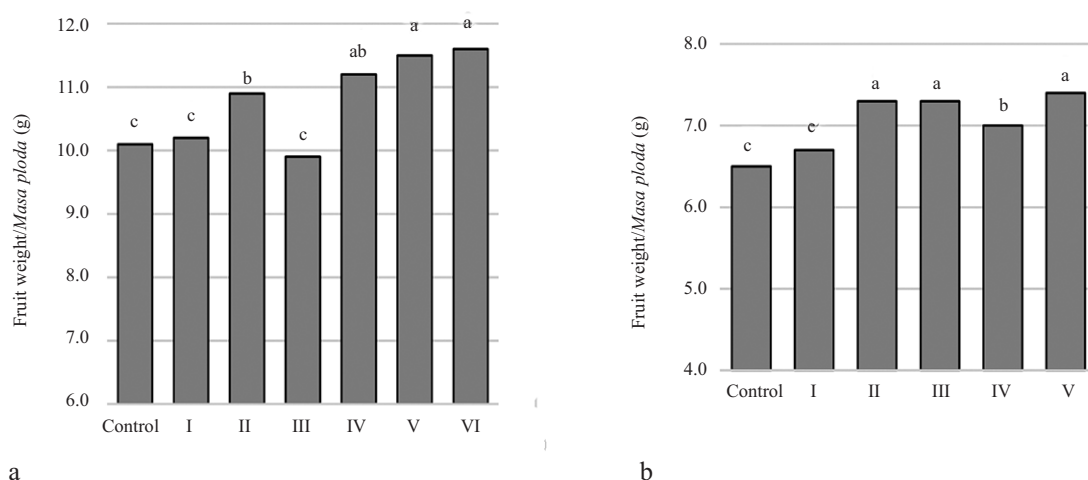
In sweet cherry cultivar 'Skeena', significant increases in fruit weight and diameter were achieved with treatments II, IV, V and VI (Graphs 2a and 3a). The highest fruit weight (11.6 g) and diameter (29.0 mm) were recorded in the treatment VI. In this treatment, the increase in fruit weight compared to the control was approximately 15%, while the average fruit diameter was 2.6 mm larger than that of the control. Slightly lower fruit weight (11.5 g) and diameter (28.9 mm) were recorded in the treatment V.

The average fruit weight of sour cherry in the control was 6.5 g (Graph 2b), with a diameter of 21.9 mm (Graph 3b). In all bioregulator treatments, fruit weight and diameter were higher compared to the control, except in the lower concentration of 'OroGibb' (treatment I), where the values were at the control level. The largest fruits were observed in the treatment V, where fruit weight reached 7.4 g, representing an increase of approximately 14% compared to the control. A significantly higher fruit weight (7.3 g) was also measured in the treatments II and III.

The highest firmness of sweet cherry fruits was observed in treatments II and V, while the lowest was found in the treatment I. No significant difference between treatments and control was observed. In sweet cherry fruits, a significantly shorter stem was recorded in the treatments I, II and III compared to the control (Table 3). 'Skeena' fruits from the treatments I, V and VI showed higher soluble solids content (SSC) compared to the control, while total acids con-

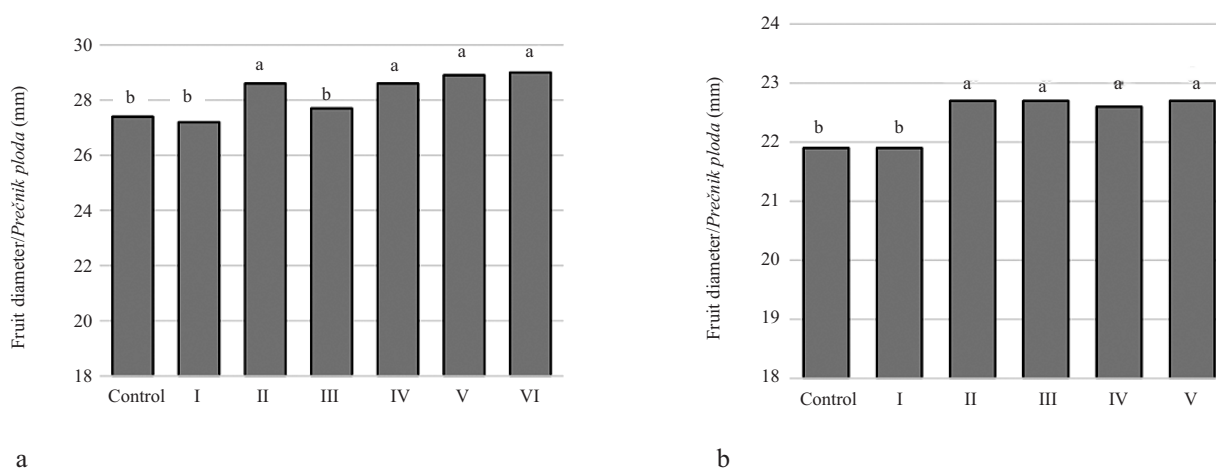


Graph 1 Fruit set of sour cherry cultivar 'Érdi Böttermö' in bioregulator treatments
Grafikon 1 Zametanje plodova kod višnje sorte Erđi botermo u tretmanima sa bioregulatorima



Graph 2 Fruit weight of sweet cherry cultivar 'Skeena' (a) and sour cherry cultivar 'Érdi Bötermő' (b) in bioregulator treatments. The bars marked by the same letter were not significantly different ($p < 0.05$)

Grafikon 2 Masa ploda trešnje sorte Skina (a) i višnje sorte Erđi botermo (b) u tretmanima sa bioregulatorima. Stubići praćeni istim slovom nisu se znaćajno razlikovali ($p < 0,05$).



Graph 3 Fruit diameter of sweet cherry cultivar 'Skeena' (a) and sour cherry cultivar 'Érdi Bötermő' (b) in bioregulator treatments. The bars marked by the same letter were not significantly different ($p < 0.05$).

Graph 3 Prećnik ploda trešnje sorte Skina (a) i višnje sorte Erđi botermo (b) u tretmanima sa bioregulatorima. Stubići praćeni istim slovom nisu se znaćajno razlikovali ($p < 0,05$).

tent was higher in treatments I, III, IV and VI than in control. However, observed differences were not statistically significant (Table 3).

Sour cherry fruits from treatment III had significantly higher fruit firmness compared to the control. Treatments I and V resulted in reductions of fruit firmness by 15.4% and 9.7%, respectively, compared to

the control treatment (Table 4). The length of the sour cherry fruit stem did not differ significantly between treatments.

Sour cherry fruits sampled in treatments I, II and III had significantly higher content of soluble solids and total acids compared to control.

Table 3. Fruit characteristics of sweet cherry cultivar ‘Skeena’ in bioregulator treatments

Tabela 3. Karakteristike plodova trešnje sorte Skina u tretmanima bioregulatorima

Treatment <i>Tretman</i>	Fruit firmness <i>Čvrstina ploda (N)</i>	Petiole length <i>Dužina peteljke (mm)</i>	SSC* <i>RSM (Brix°)</i>	TA <i>UK (%)</i>
Control	17.9 ab	39.1 a	14.8 a	0.96 a
I	16.5 b	36.2 bc	14.9 a	1.06 a
II	18.2 a	36.2 bc	14.8 a	0.83 a
III	17.6 ab	34.1 c	14.8 a	1.06 a
IV	17.8 ab	37.6 ab	14.8 a	1.13 a
V	18.3 a	37.1 ab	17.3 a	0.93 a
VI	17.9 ab	37.7 ab	16.7 a	1.03 a

*SSC – soluble solids content; TA – total acids content / *RSM – sadržaj rastvorljive suve materije; UK – sadržaj ukupnih kiselina;*The values in the same column followed by the same lower case letter are not significantly different ($p < 0.05$) / *Prosečne vrednosti u svakoj koloni praćene istim malim slovom nisu statistički značajno različite* ($p < 0.05$).

Table 4. Fruit characteristics of sour cherry cultivar ‘Ērdi Bőtermő’ in bioregulator treatments

Tabela 4. Karakteristike plodova višnje sorte Erđi botermo u tretmanima bioregulatorima

Treatment <i>Tretman</i>	Fruit firmness <i>Čvrstina ploda (N)</i>	Petiole length <i>Dužina peteljke (mm)</i>	SSC* <i>RSM (Brix°)</i>	TA <i>UK (%)</i>
Control	5.2 b	37.7 a	11.9 cd	1.11 b
I	4.4 d	39.9 a	15.1 a	1.37 a
II	5.3 ab	39.7 a	14.8 a	1.38 a
III	5.7 a	40.0 a	13.8 ab	1.36 a
IV	5.0 bc	39.6 a	13.2 bc	1.19 ab
V	4.7 cd	41.0 a	11.4 d	0.99 b

*SSC – soluble solids content; TA – total acids content / *RSM – sadržaj rastvorljive suve materije; UK – sadržaj ukupnih kiselina;*The values in the same column followed by the same lower case letter not significantly different ($p < 0.05$) / *Prosečne vrednosti u svakoj koloni praćene istim malim slovom nisu statistički značajno različite* ($p < 0.05$).

Discussion

Fruit set in sour cherries can be classified into five categories: very low (less than 10%), low (10–20%), moderate (20–30%), high (30–40%), and very high (above 40%) (Nyéki *et al.*, 2003). The same authors suggest that during abundant flowering, a fruit set of 20–30% is required to achieve a high yield per unit area (15–20 t ha⁻¹). In our study, fruit set ranged from 10.7% to 27.4%. Previous studies have reported that the effect of GA₃ on fruit set depends on the applied concentration, timing of application, fruit species, and cultivar. It can enhance fruit set (Stopar, 2018), reduce it (Beppu *et al.*, 2001), or have no effect (Sabir *et al.*, 2021).

The applied GA₃ treatments generally increased the fruit weight and diameter of sour and sweet cherries (Graphs 2 and 3). Our findings align with those of Cline & Trought (2007), who reported that the appli-

cation of GA₃ increased the fruit weight of the ‘Skeena’ cultivar by 17%. Similarly, Ozkan *et al.* (2016) found that GA₃ applied at concentrations 30 and 60 ppm enhanced the fruit weight and diameter of the ‘Sweetheart’ cultivar. Gibberellins promote cell division and elongation, leading to increased fruit size. In the studies conducted by Canli *et al.* (2015a), the effect of BA on fruit weight and diameter was found to depend on the applied concentration. They emphasized that the highest increase in the fruit weight of the cherry cultivar ‘Noir de Guben’ occurred at a concentration of 150 ppm among the tested concentrations of 50, 100, and 150 ppm. Our findings are consistent with these results, showing that the effect of BA depends on the fruit species, the concentration used, and the number of treatments. The application of NAA treatments increased fruit weight of cherries by 5.8% to 11.9%, depending on the cultivar studied (Clayton-Cuch *et al.*, 2021; Zeman *et al.*, 2013). Our results support these

findings, with ‘FrutaFija’ increasing fruit weight by 14%.

The application of GA₃ influences the increase in cherry fruit firmness (Einhorn *et al.*, 2013) by reducing the activity of the enzymes pectin methylesterase and polygalacturonase, which are involved in cell wall softening (Atkinson *et al.*, 2012). Our results are partially consistent with previous studies, showing that treatments with ‘OroGibb’ and ‘GranPera’, which contain GA₃, increased fruit firmness in sour cherry depending on the applied concentration, while no significant effect was observed for this parameter in sweet cherry. In the study by Clayton-Cuch *et al.* (2021), it was reported that cherries treated with NAA had lower fruit firmness at harvest, a finding confirmed in our research. Sour cherry fruits treated with ‘FrutaFija 20’ exhibited reduced firmness at harvest compared to the control fruits.

Sweet cherry fruits with long pedicels are preferred by consumers (Canli & Orhan, 2009). Depending on the applied concentration, BA treatments can increase the peduncle length of cherry fruits, as noted in the studies by Canli *et al.* (2015a). Similarly, Horvitz *et al.* (2003) reported that GA₃ treatments could also enhance peduncle length. However, there are reports suggesting that GA₃ does not affect peduncle length (Canli & Orhan, 2009). In our study, the applied treatments did not influence the peduncle length of sour cherries, while treatments I, II and III resulted in a reduction in peduncle length in sweet cherries. For cultivar ‘Skeena’, which naturally has a short stem, this could negatively affect harvest efficiency.

Treatments I, II and III increased the SSC and TA content in sour cherry fruits, while no effect was observed in sweet cherries. Contrary to our results, previous studies have shown that GA₃ and BA treatments increased SSC content in sweet cherry fruits. However, Giardina *et al.* (2010) reported that BA treatments reduced SSC content in sweet cherry fruits. Similarly, Zeman *et al.* (2013) stated that NAA treatment did not affect SSC content in sweet cherry fruits, which aligns with our findings.

The aforementioned authors emphasize that the effect of bioregulators on these parameters depends on factors such as the applied concentration, timing of application, and cultivar.

Conclusion

In sweet cherry, the treatments II (‘OroGibb’ at 20 mg l⁻¹ a.i., applied at BBCH 67 stage), IV (‘GranPera’ at 10 mg l⁻¹ a.i., applied two times at BBCH 76 stage), V (‘GranPera’ at 20 mg l⁻¹ a.i., applied at BBCH 67 stage) and VI (‘GranPera’ at 20 mg l⁻¹ a.i., applied two times at BBCH 76 stage) increased fruit weight and diameter. The effects of applied treatments on firmness were inconsistent, and no significant impacts were observed on the contents of total soluble solids or acids.

‘OroGibb’ at 10 mg l⁻¹ a.i., applied at the stages of flower fading and pit hardening (treatment I), increased fruit set of sour cherry but without positive effect on fruit size. The application of ‘GranPera’ (treatments III and IV), ‘FrutaFija’ (treatment V) and higher concentration ‘OroGibb’ (treatment II) improved the fruit size of studied sour cherry cultivar, while only application of lower concentrations of ‘GranPera’ (treatment III) had a positive effect on fruit firmness. ‘OroGibb’ (treatments I and II) at both tested concentrations and ‘GranPera’ at 10 mg l⁻¹ a.i. (treatments III) increased contents of total soluble solids and total acids.

Acknowledgements

The research was financed by the Provincial Secretariat for Higher Education and Scientific Research, project title: ‘Bioregulators and biostimulators in orchard cultivation as a measure of adaption to climate change’, number of the agreement: 000855717 2024 09418 003 000 000 001 04 002.

References

- Abdel-Mohsen M., Kamel H. (2015): Fruit set and quality of ‘caino’ apricot fruits as affected by spraying with yeast, growth regulators and micronutrients. *Journal of Plant Production*, 6(8): 1431–1441.
- Arteca R. N. (1996): *Plant growth substances: Principles and applications*. New York: Chapman & Hall.
- Atkinson R.G., Sutherland P.W., Johnston S.L., Gunaseelan K., Hallett I.C., Mitra D., Brummell D.A., Schröder R., Johnston J.W., Schaffer R.J. (2012): Down-regulation of polygalacturonase1 alters firmness, tensile strength and water loss in apple (*Malus × domestica*) fruit. *BMC Plant Biology*, 12(129).

- Basak A., Rozpara E., Grzyb Z. (1998): Use of bioregulators to reduce sweet cherry tree growth and to improve fruit quality. *Acta Horticulturae*, 468: 719–723.
- Beppu K., Suehara T., Kataoka I. (2001): Embryo sac development and fruit set of “Satohishiki” sweet cherry as affected by temperature, GA₃ and paclobutrazol. *Journal of the Japanese Society for Horticultural Science*, 70(2): 157–162.
- Canli F.A., Orhan H. (2009): Effects of preharvest gibberellic acid applications on fruit quality of “0900 Ziraat” sweet cherry. *HortTechnology*, 19(1): 127–12.
- Canli F.A., Pektas M., Ercisli S. (2015a): Benzyladenine and gibberellin applications improve fruit weight and delay maturity of sweet cherry. *Erwerbs-Obstbau*, 57(2): 71–75.
- Canli F.A., Sahin M., Ercisli S. (2015b): Harvest and postharvest quality of sweet cherry are improved by pre-harvest benzyladenine and benzyladenine plus gibberellin applications. *Journal of Applied Botany and Food Quality*, 88: 255–258.
- Chapon J.F., Westercamp P. (1996): *Entrepotage frigorifique des pommes et des poires*, tome 2: Conduite de la conservation, CTIFL, Paris.
- Choi C., Tao R., Andersen R.L. (2002): Identification of self-incompatibility alleles and pollen incompatibility groups in sweet cherry by PCR based s-allele typing and controlled pollination. *Euphytica*, 123(1): 9–20.
- Clayton-Cuch D., Yu L., Shirley D., Bradley D., Bulone V., Bottcher C. (2021): Auxin treatment enhances anthocyanin production in the non-climacteric sweet cherry (*Prunus avium* L.). *International Journal of Molecular Sciences*, 22: 10760.
- Cline J.A., Trought M. (2007): Effect of gibberellic acid on fruit cracking and quality of Bing and Sam sweet cherries. *Canadian Journal of Plant Science*, 87(3): 545–550.
- Correia S., Queirós F., Ribeiro C., Vilela A., Aires A., Barros A.I., Schouten R., Silva A.P., Gonçalves B. (2019): Effects of calcium and growth regulators on sweet cherry (*Prunus avium* L.) quality and sensory attributes at harvest. *Scientia Horticulturae*, 248: 231–240.
- Einhorn T.C., Wang Y., Turner J. (2013): Sweet cherry fruit firmness and postharvest quality of late-maturing cultivars are improved with low-rate, single applications of gibberellic acid. *HortScience*, 48(8): 1010–1017.
- Fadóna E., Herreroa M., Rodrigo J. (2015): Flower development in sweet cherry framed in the BBCH scale. *Scientia Horticulturae*, 192: 141–147.
- Giardina G., Reeb P., Dussi M. C., Gastiazoro J., Zon K., Nichols J., Nyéki J., Szabó Z., Pugh B., Racsko J. (2010): Benzyladenine effects on fruit quality of Swrtheart and Lapins sweet cherry. *Acta Horticulturae*, 884: 473–479.
- Horvitz S., Godoy C., López Camelo A.F., Yommi A. (2003): Application of gibberellic acid to sweetheart sweet cherries: Effect on fruit quality at harvest and during cold storage. *Acta Horticulturae*, 628: 311–316.
- Kalajdžić J., Milić B., Petreš M., Stankov A., Grahovac M., Magazin N., Keserović Z. (2019): Postharvest quality of sweet cherry fruits as affected by bioregulators. *Acta Sci. Pol. Hortorum Cultus*, 15(5): 189–199.
- Kantaroglu, M., Demirbaş N. (2020): Technical and economic factors affecting losses in sweet cherry production: A case study from Turkey. *International Journal of Fruit Science*, 20(3): 1994–2004.
- Kappel F., MacDonald R.A. (2002): Gibberellic acid increases fruit firmness, fruit size, and delays maturity of “Sweetheart” sweet cherry. *Journal of the American Pomological Society*, 56(4): 219–222.
- Kuhn N., Maldonado J., Ponce C., Arellano M., Time A., Multari S., Martens S., Carrera E., Donoso M. J., Sagredo B., Meisel L.A. (2021): RNAseq reveals different transcriptomic responses to GA₃ in early and midseason varieties before ripening initiation in sweet cherry fruits. *Nature Portfolio*, pp. 1–20.
- Lenahan O.M., Whiting M.D., Elfving D.C. (2006): Gibberellic acid inhibits floral bud induction and improves ‘Bing’ sweet cherry fruit quality. *HortScience*, 41(3): 654–659.
- Milić B., Tarlanović J., Keserović Z., Magazin N., Miodragović M., Popara G. (2018): Bioregulators can improve fruit size, yield and plant growth of northern highbush blueberry (*Vaccinium corymbosum* L.). *Scientia Horticulturae*, 235: 214–220.
- Milić B., Tarlanović J., Keserović Z., Zorić L., Blagojević B., Magazin N. (2016): The growth of apple central fruits as affected by thinning with NAA, BA and naphthenic acids. *Erwerbs-Obstbau*, 59(3): 185–193.
- Nyéki J., Szabó Z., Soltész M. (2003): Sour cherry (*Prunus cerasus* L.). In P. Kozma, J. Nyéki, M. Soltész, & Z. Szabó (Eds.), *Floral biology, Pollination and Fertilisation in Temperate Zone Fruit Species and Grape*, pp. 359–382.
- Ozkan Y., Ucar M., Yildiz K., Ozturk B. (2016): Pre-harvest gibberellic acid (GA₃) treatments play an important role on bioactive compounds and fruit quality of sweet cherry cultivars. *Scientia Horticulturae*, 211: 358–362.
- Pehlivan M., Bozhüyük M.R., Doğru B., Özden E., Aslantaş R. (2012): Giberalik Asit (GA₃) Uygulamalarının 0900-Ziraat Kiraz Çeşidinin Bazı Meyve Özelliklerine Etkileri. *Atatürk Üniversitesi Ziraat Fakültesi Dergisi*, 43(1): 7–11.
- Sabir I. A., Liu X., Jiu S., Whiting M., Zhang C. (2021): Plant growth regulators modify fruit set, fruit quality, and return bloom in sweet cherry. *HortScience*, 56(8): 922–931.
- Statistical Office of the Republic of Serbia (2023): Available online: <http://www.stat.gov.rs/>
- Stopar M. (2018): Sweet cherry (*Prunus avium* L.) fruit drop reduction by the application of 1- naphthaleneacetic acid and gibberellic acid. *Acta Horticulturae*, 1221: 71–74.
- Thakur Y. (2016). Effect of plant growth regulators on growth, yield and fruit quality of strawberry (*Fragaria x ananassa* Duch.) under protected condition. Master of Science (Horticulture) Fruit Science. University of Horticulture and Forestry (Nauni) Solan, India.
- Zeman S., Jemrić T., Čmelik Z., Fruk G., Bujan M., Tompić T. (2013): The effect of climatic conditions on sweet cherry fruit treated with plant growth regulators. *Journal of Food, Agriculture & Environment*, 11(2): 524–528.
- Zhang C., Whiting M.D. (2011): Improving “Bing” sweet cherry fruit quality with plant growth regulators. *Scientia Horticulturae*, 127(3): 341–346.

UTICAJ BIOREGULATORA I BIOSTIMULATORA NA KVALITET PLODOVA TREŠNJE I VIŠNJE**Biserka Milić¹, Nenad Magazin¹, Zoran Keserović¹, Maja Milović¹, Jelena Kalajdžić¹, Stefan Gligorić¹, Jelena Savićević²**¹Univerzitet u Novom Sadu, Poljoprivredni fakultet, Trg Dositej Obradovića 8, 21000 Novi Sad, Republika Srbija

*E-mail: biserka.milic@polj.uns.ac.rs

²Dedovina d.o.o., Koštunići 280, 32300 Gornji Milanovac, Republika Srbija**Rezime**

Bioregulatori igraju značajnu ulogu u poboljšanju zamatiranja, mase i čvrstine plodova, pa je cilj ovog istraživanja bio da se ispita efekat primene preparata na bazi giberelinske kiseline, 6-benziladenina i α -nafi-til sirćetne kiseline na zamatiranje i kvalitet plodova sorte trešnje Skina i sorte višnje Érdi Bötermö. Tretmani primenjeni kod trešnje su uključivali primenu preparata OroGibb (GA_3 1,6 % + BA 1,6 % + B) i GranPera (GA_3 2% + P, K), u koncentracijama 10 mg l⁻¹ i 20 mg l⁻¹ aktivne materije (a.m.), u precvetavanju (BBCH 67) ili u momentu kada su plodovi dostigli 60% konačne veličine (BBCH 76). Primenjeni su sledeći tretmani: I (OroGibb u koncentraciji 10 mg l⁻¹ a.m., primenjen u fazi BBCH 67); II (OroGibb u koncentraciji 20 mg l⁻¹ a.m., primenjen u fazi BBCH 67); III (GranPera u koncentraciji 10 mg l⁻¹ a.m., primenjen u fazi BBCH 67); IV (GranPera u koncentraciji 10 mg l⁻¹ a.m., primenjen dva puta u fazi BBCH 76); V (GranPera u koncentraciji 20 mg l⁻¹ a.m., primenjen u fazi BBCH 67); VI (GranPera u koncentraciji 20 mg l⁻¹ a.m., primenjen dva puta u fazi BBCH 76). Pored preparata OroGibb i GranPera, kod višnje je korišćen i biostimulator FrutaFija (amino kiselina 4,5%; P₂O₅ 13%; K₂O 18%; B 0,5%; Fe 0,04%; Cu 0,01%). Preparati su primenjeni u dve koncentracije (10 mg l⁻¹ i 20 mg l⁻¹ a.m.) i u dva termina: na kraju cvetanja (BBCH 69) i u momentu kada su plodovi dostigli 60% konačne veličine (BBCH 76). Ustanovljeni su sledeći

tretmani: I (OroGibb u koncentraciji 10 mg l⁻¹ a.m., primenjen u fazama BBCH 69 i BBCH 76); II (OroGibb u koncentraciji 20 mg l⁻¹ a.m., primenjen u fazama BBCH 69 i BBCH 76); III (GranPera u koncentraciji 10 mg l⁻¹ a.m., primenjen u fazama BBCH 69 i BBCH 76); IV (GranPera u koncentraciji 20 mg l⁻¹ a.m., primenjen u fazama BBCH 69 i BBCH 76); V (FrutaFija u koncentraciji 20 mg l⁻¹ a.m., primenjen u fazi BBCH 69). U ogled su bila uključena i netretirana stabla koja su predstavljala kontrolu. Najveća masa (11,6 g) i prečnik (29,0 mm) ploda sorte trešnje Skina uočeni su u tretmanu VI. Primenjeni tretmani nisu uticali na čvrstinu ploda, kao ni na sadržaj rastvorljive suve materije i sadržaj ukupnih kiselina u plodu ispitivane sorte trešnje. Najviše vrednosti zamatiranja plodova sorte višnje Érdi Bötermö uočene su u tretmanu I (27,4%), međutim jedino plodovi iz ovog tretmana se u pogledu mase i prečnika ploda nisu značajno razlikovali u odnosu na kontrolu, dok su u svim ostlim tretmanima uočene značajno više vrednosti. Plodovi višnje iz tretmana III su se odlikovali značajno višim vrednostima čvrstine ploda, dok su se plodovi iz tretmana I, II i III odlikovali višim sadržajem rastvorljive suve materije i ukupnih kiselina.

Ključne reči: koštičavo voće, GA_3 , BA, NAA, zamatiranje plodova, masa ploda, čvrstina ploda, ukupna kiselost