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Sweet Cherry (*Prunus avium* L.) Fruit Drop Reduction by Plant Growth Regulators (Naphthalene Acetic Acid NAA and Gibberellic Acid GA_3)

Ammar Askarieh[1], Sawsan Suleiman[2], Mahasen Tawakalna[3]

[1]Agricultural Scientific Research Center in Lattakia, General Commission for Scientific Agricultural Research, Damascus, Syria
[2]Horticulture Department, Faculty of Agriculture, Tishreen University, Lattakia, Syria
[3]Administration of Horticulture Research, General Commission for Scientific Agricultural Research, Damascus, Syria
Email: *ammar.askarieh89@gmail.com

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Abstract

This study was conducted during 2019/2020 on sweet cherry trees (*Prunus Avium* L.) (Bing and Hardy Giant) cultivar planted at Sergaya-Al_Zabadani area of Rural Damascus, to reduce fruit drop of sweet cherry. The experiment included 4 foliar applications: T1: control, T2: GA_3 (100 ppm), T3: NAA (20 ppm), T4: (100 ppm GA_3 + 20 ppm NAA). Fruit set and fruit drop percentage, fruiting factor, and yield were recorded. The results showed that treatment with (100 ppm GA_3 + 20 ppm NAA) recorded higher fruit set percentage (73.81% and 75.62%), and fruiting factor (48.38% and 50.04%) respectively; In addition to fruit yield (40.19 and 41.21 kg/tree) for both cultivars, compared to the control (9.13, 6.60 kg/tree). Therefore, it can be concluded that GA_3 + NAA treatment reduced Sweet cherry fruit drop better than other treatments, where fruit drop percentage didn't exceed (63.11% and 62.01%) in both cultivars (Bing and Hardy Giant) respectively, compared to the control (80.92% and 80.64%).

Keywords

Sweet Cherry, Naphthalene Acetic Acid (NAA), Gibberellic Acid (GA_3), Fruitset, FruitDrop

1. Introduction

Plant growth regulators or plant hormones are organic substances that are naturally produced in high plants. They control and activate growth and physiologi-

cal functions at low concentrations and far from their production site. Use of growth regulators has become an important way in agriculture, especially in fruit trees, such as spraying auxin and Gibberelline, which are widely used to reduce fruit drop and improve their quality [1].

The balance of internal hormones plays a main important role in nutrients distribution's in plant's organs and affects bud longevity. It has been confirmed that fruit drop is due to internal content of auxin by external application 2,4-D or NAA, where the transport of auxins by plant stays for a long time without any effect of ethylene [2], and it's found that gibberellic acid delays ripening and aging of fruits [3].

In an experiment on 3 sweet cherries varieties (Sweet Heart, Sunburst, Lapins) to improve fruitset, the trees were sprayed with a mixture of (10 mg/l GA_3, 10 mg/l NAA) with a week intervals, where the first spray was at the end of flowering, The results showed that fruitset percent was improved by at least 2 times compared with control [4].

Many researches and experiments indicated that repeated application of gibberellic acid (GA_3) improved fruitset and reduced fruit drop of cherry trees in rainy years [5].

Application of gibberellic acid (100 ppm) on peach trees, increased the fruitset percentage (69.70%) compared to the control (58%), and production (63.23 kg/tree), compared to the control (52.6 kg/tree) [6].

Tuan & Chung-Ruey [7] confirmed that foliar spray of apple trees (wax apple) with GA_3 (30 ppm) at the young bud and petal fall stages caused a significant increase in the fruitset percentage, this may be due to the increase in the availability of nutrients from the leaves by gibberellic, similar results were obtained on (wax apple) by Moneruzzaman *et al.* [8] as well as on sweet oranges [9].

The results of foliar application with a mixture of (GA_3 100 mg/l + 100 mg/l NAA) on olive trees showed a higher fruitset percentage (4.78%) compared to control (2.89%) [10].

The study of sweet orange trees (Nucellar) treatment with NAA (15, 20, 25 ppm), improved that the lowest fruit drop percentages (14.19%) was recorded with 15 ppm, and the highest fruitset percentage (64.57%) were at 25 ppm [11].

Treatment of sweet orange trees (*Citrus sinensis* Osbeck.) Cv. Jaffa with three concentrations of NAA (20, 30, 40 ppm) showed that 20 ppm achieved the highest fruit drop reduction until harvest, the highest fruit retained percentage, the largest number of fruits/tree and the highest production/tree [12].

In an experiment on mandarin trees 10 years old, it was observed that application of NAA (10 mg/l) increased fruitset percentage (82.77%), the largest number of fruits/tree and the highest productivity [13]. As well as spray of navel orange trees with (GA_3 ppm 20 + NAA ppm 25) reduced the fruit drop percentage and increased productivity (kg/tree) [2].

Sweet cherry trees planted in the study area (Sargaya) suffer from fruit drop, which affects productivity, and according to the importance of growth regulators

in increasing the fruitset, reducing fruit drop and increasing productivity, this research was conducted by application Naphthalene acetic acid (NAA) and Gibberellic acid (GA_3) to resolve this problem.

2. Materials and Methods

The search was carried out at Cherry orchard located in Sargaya, Al-Zabadani area in Rural Damascus, at about 1500 meters altitude from sea level on sweet cherry trees (*Prunus avium* L.), Bing and Hardy Giant, 20 years old, grafted on *Prunus mahaleb*. The treatment included: (T1: Control "sprayed with water only", T2: GA_3 at 100 ppm, T3: NAA at 20 ppm, T4: (100 ppm GA_3 + 20 ppm NAA), teen 20 was added 1 ml/l growth regulator solution. At white balloon and after fruitset stages for NAA application, and after fruitset for GA_3 application. The experiment was designed by the complete randomized method, with 4 treatments repeated 3 times and 1 tree was used for each treatment. 4 similar flowering branches on each tree were selected, and the number of flowers on each tagged branch for a particular treatment counted. All treatments were performed with a manual hand sprayer to the drip-point. The results were analyzed statistically and analysis of variance (ANOVA) was performed using the statistical program Genstat-12. The lowest significant difference LSD was calculated at the level of 5% coefficients to compare the mean and find out the significant differences, after angular conversion of percentages. The studied parameters were:

- Mean of (total flowers/branch, fruitsets/branch, fruits drop/branch, and ripe fruits/branch)
- **Fruitset percentage:**

$$FS = \frac{FSn}{TFn} \times 100$$

FS: Fruitset percentage (%),
FSn: fruitset number,
TFn: Total flowers number.

- **Fruit drop percentage:**

$$FD = \frac{FDn}{FSn} \times 100$$

FD: Fruit drop percentage (%),
FDn: fruit drop number,
FSn: fruitset number.

- **Fruiting factor:**

$$FF = \frac{Fn}{TFn} \times 100$$

FF: Fruiting factor (%),
Fn: Fruit number at harvest time,
TFn: Total flowers number.

- Fruit weight Mean: A random sample (150 fruits) was taken from the two studied varieties, with 50 fruits of each replicate, and weighed.
- Tree production (kg): Fruit trees weight was performed and mean fruit production was calculated for each treatment.

3. Results and Discussion

3.1. Effect of GA_3 and NAA on Fruitset Percentage

The results showed that fruitset percentage was increased with NAA treatment (76.43%) compared to control (72.76%) for the Bing variety. While it was (72.85%) with GA_3 without significant differences with control. For Hardy Giant variety fruitset was increased as well with GA_3 + NAA application (73.81%) compared to the other studied treatments, with no significant differences between control (71.59%) and GA_3 treatment (71.66%), Table 1.

These results are in agreement with the results of Stopar [4] who recommended the foliar spray with a mixture of (GA_3 10 mg/l + NAA 10 mg/l) as a technical application to increase fruitset percentage for all sweet cherry varieties.

These results agreed with Bubán [14] who indicated that using growth regulators in order to improve the final fruitset percentage in cherry trees is considered ineffective compared to other types of fruit trees such as pears, despite the presence of many previous studies confirming the possibility of using some growth regulators to obtain good fruitset percentage in the cherry trees too.

Table 1. Effect of spraying GA_3, NAA on fruitset percentage.

	Mean of total flowers/branch	Mean of fruitset/branch	Fruitset percentage %	Fruitset percentage % after angular conversion
		Bing		
T1: Control	76.75	63.75	83.20	72.76b
T2: GA_3	96.91	80.67	83.33	72.85b
T3: NAA	101.91	91.00	89.29	76.43a
T4: GA_3 + NAA	94.66	83.50	88.03	75.62a
LSD 5%	-	-	-	**1.555**
		Hardy Giant		
T1: Control	117.41	95.16	81.05	71.59c
T2: GA_3	81.91	66.50	81.18	71.66c
T3: NAA	78.00	64.91	83.26	72.79b
T4: GA_3 + NAA	119.25	101.41	85.05	73.81a
LSD 5%	-	-	-	**0.866**

*Values that have the same letters within the same column have no significant difference between them at LSD 5%.

3.2. Effect of GA_3 and NAA on the Percentage of Fruit Drop and Fruiting Factor

The results showed the (GA_3 + NAA and GA_3) treatments decreased fruit drop percentage in Bing (62.01% and 77.68%) respectively, compared to the control (80.64%). In Hardy Giant, application of GA_3 + NAA, decreased as well fruit drop percentage (63.11%) with no significant differences with NAA (63.47%), table (2). The results showed as well that no significant differences between control (80.92%) and GA_3 treatment (80.13%), Table 2.

Many researches have succeeded in reducing fruit drop and increasing many varieties of sweet cherries production by foliar application with a mixture of GA_3 + NAA after a short period of flowering [15] [16]. Plant growth regulators (PGR's) are known to have a great influence on dropping and maintain fruits on trees. An imbalance of auxins, cytokinins, and gibberellins may lead to the formation of a separation layer at the point of contact with branch, causing fruit drop [17]. Fruit drop reduction due to the application of growth regulators can be attributed to the compensation for endogenous auxin deficiency prevents the formation of a separation layer by inhibiting enzymatic activity by pectinase and polygalacturonase [18] [19] [20].

Table 2 showed as well that fruiting factor significantly increased with GA_3 + NAA application in both cultivars (Bing and Hardy Giant) (48.38%, 50.04%), with no significant difference with NAA (47.68% and 47.05%), compared to the

Table 2. Effect of spraying GA_3, NAA on the drop percentage and fruiting factor.

	Mean of Fruits drop/branch	Mean of Ripe fruits/branch	Fruit drop percentage %	Fruit drop percentage % after angular conversion	Fruiting factor %	Fruiting factor % % after angular conversion
			Bing			
T1: Control	60.50	3.25	78.67	80.64d	4.53	27.04c
T2: GA_3	73.50	7.17	75.89	77.68c	7.44	31.45b
T3: NAA	6.75	29.25	60.58	65.17b	28.70	47.05a
T4: GA_3 + NAA	50.25	33.25	53.49	62.01a	34.54	50.04a
LSD 5%				**2.727**		**3.969**
			Hardy Giant			
T1: Control	90.41	4.75	77.02	80.92b	4.03	26.50c
T2: GA_3	62.5	5.33	76.23	80.13b	6.50	30.32b
T3: NAA	41.58	23.33	53.35	63.47a	29.50	47.68a
T4: GA_3 + NAA	64.25	37.16	53.79	63.11a	31.26	48.38a
LSD 5%				**3.428**		**2.423**

*Values that have the same letters within the same column have no significant difference between them at LSD 5%.

control (26.50% and 27.04%), respectively.

Similar results were obtained in previous experiments conducted by Stopar [4] on (Sunburst, Lapins and Sweetheart) cultivars, and by Webster *et al.* [5] who found that remaining fruits number on Colney's sweet cherry trees increased 2 times when sprayed with a mixture of (GA_3 10 mg/l + NAA 10 mg/l). On the other hand, this treatment did not have any effect on Stella cultivar, it would be concluded that Bing cultivar behavior differed to GA_3 Application than Hardy Giant, while the 2 cultivars behaved similar to NAA treatment, so varieties behavior differs to growth regulators application.

This result is in agreed with Sweety *et al.* [12] who attributed the higher fruiting factor in NAA (20 ppm) treatments to the reduction of fruit drop, where growth regulators treatment compensated the lack of endogenous auxin, thereby preventing the formation of the separation layer, possibly by inhibiting Enzymatic activity.

3.3. Effect of GA_3 and NAA on Fruit Weight and Yield

Table 3 indicated as well a significant effect of GA_3 (7.447 and 8.800 g/fruit) compared to other treatments included the control for Bing and Hardy Giant, respectively.

This result showed that the increase of fruit yield is due to the enhancement of fruit weight by GA_3 application, not for fruitset percentage. This is confirmed by Zhang [20] results, where GA_3 (100 mg/l) application had a positive effect on fruits weight of sweet cherry Bing cultivar, while the (200 mg/l) was more effective in increasing fruits weight by 15% compared to the control.

Table 3 showed that (GA_3, NAA and GA_3 + NAA) application enhanced Bing fruit yield (14.78, 28.89 and 40.21 kg/tree), and Hardy Giant fruit yield (11.06, 22.69 and 40.19 kg/tree), compared to the control (Bing and Hardy Giant) (5.93 and 9.13 kg/tree) respectively.

These results agreed with Stopar [4], who observed that sweet cherry trees' yield increased 2 times when sprayed with a mixture of (GA_3 10 mg/l + NAA 10

Table 3. Effect of GA_3 and NAA on fruit weight and yield (kg/tree).

	Bing		Hardy Giant	
	Mean of fruit weight/g	Yield Kg/tree	Mean of fruit weight/g	Yield Kg/tree
T1: Control	6.670b	5.93d	7.770b	9.13c
T2: GA_3	7.447a	14.78c	8.800a	11.06c
T3: NAA	6.320c	28.89b	7.600b	22.69b
T4: GA_3 + NAA	6.667b	41.21a	7.640b	40.19a
LSD 5%	**0.321**	**7.444**	**0.212**	**5.530**

*Values that have the same letters within the same column have no significant difference between them at LSD 5%.

mg/l) compared to non-sprayed trees.

This result is in agreement with [21] [22] [23] who showed that spraying of orange trees with NAA and GA_3 increased trees yield compared to non-sprayed trees.

Yield increase in the studied treatments compared to the control could be attributed to the increase in fruits remained number at harvest time. The enhancement of fruit weight may be due to the activation and increase of cell division and cell elongation by NAA and GA_3 treatments [24].

Agrawal and Dikshit [25] showed that NAA treatment increased fruit weight and yield as a result of activating cell elongation, increasing vacuole size, flexibility, and cell wall elasticity. Stern *et al.* [26] also indicated that NAA treatment promotes cell elongation in mesocarp cells, thus increasing fruit size and yield.

4. Conclusion

It can be concluded that the application of the mixture of (20 ppm NAA + 100 ppm GA_3) on cherry trees had a positive effect in reducing fruit drop percentage and increasing fruiting factor compared to the control. NAA + GA_3 application was more effective than NAA alone. The efficacy of the GA_3 + NAA mixture should be further investigated.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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