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Influence of 1-naphthylacetic acid on pre-harvest fruit drop and quality of Idared apples

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Abstract

The research was carried out during 2016, in the intensive apple orchard founded near the village of Păulești, Călărași district, in the autumn of 2006 at the company S.R.L."Codru ST". The object of the study were trees of the Idared variety grafted on rootstock M9. The trees were trained on the improved super spindle crown. Plant spasing is 3.5 x 1.2 m. The growth regulator Obsthormon 24a plays an important role in preventing pre-harvest fruit drop in the intensive apple plantations of different varieties, to maintain physiological balance in the plant and to keep as much as possible fruit in the crown at harvest time. To achieve this aim, the following variants were studied: 1. Without treatment (control); 2. Obsthormon 24a - 200 ml/ha; 3. Obsthormon 24a - 300 ml/ha; 4. Obsthormon 24a - 400 ml/ha; 5. Obsthormon 24a - 500 ml/ha; 6. Obsthormon 24a - 200+200 ml/ha; 7. Obsthormon 24a - 200+300 ml/ha. Investigations carried out show that the growth regulator Obsthormon 24a can be included in the technological system for the prevention of premature fruit drop before harvesting of Idared apple production when the treatment was carried out in two steps at the dose 200+300 ml/ha. The first treatment to be applied in the first decade of July, when bud differentiation starts on apple, and the next one 15 days before harvest.

Keywords: apple, auxin, stress, drop, firmness, production, quality.

Introduction

The exclusion of premature fruit drop in the pre-harvest and harvest period is a useful crop management tool that apple growers need to consider each year [3,5]. Each variety is prone in its own way in terms of the tendency for pre-harvest fruit drop [1,11]. Pre-harvest and harvest fruit drop begins about 4 weeks before harvest time and can invoke yield losses in some years of up to 50% [10,11]. This phenomenon may be due to hormonal imbalance, caused by auxin deficiency [7]. Climatic conditions, nutrition, soil type and tree health are all factors that have a major influence on fruit drop before harvest [1,8].

Trees with excessive nitrogen content at the end of the growing season and with a high crop load have the highest tendency to fruit drop. Trees deficient in magnesium or boron are also more prone to pre-harvest drop. Trees that are stressed, be it by lack of moisture in the soil or leaf damage by diseases, insects (mites), have a higher tendency to fall before harvest. Unusually hot days and warm nights just before and during the harvest period will accentuate fruit drop [1,2,13]. Growth regulators are substances that act on plant physiology to alter development by delaying pre-harvest drop or fruit ripening [12,14].

1-Naphthylacetic acid (NAA) is a synthetic, hormone-like auxin that should be applied under conditions that favour good foliar uptake, which delays the destruction of cells in the abscission zone and allows to control pre-harvest drop [6,15,18]. The best results are obtained when applied by foliar spraying, which ensures a more uniform degree of leaf and fruit absorption, which is important because the product is systemic only locally [12,16]. The higher volume of water also slows drying time, which allows for greater absorption. Air temperature also influences the absorption rate, and the optimal temperature range is 21-24°C and high humidity. Absorption rate is negatively affected if leaves have been affected by insects, diseases or frost and at temperatures below 16°C [6,9].

NAA is fast acting and cessation of fruit drop can be observed within 2-3 days after application [10,12]. Premature fruit drop can be controlled for 7-10 days with a single application of NAA at 10-20 ppm [10,12,14]. A split application of NAA provides control of preharvest drop for 10-14 days after the first application. The application can be included in pre-harvest cover treatments [11,12,17].

Material and Method

The research was carried out during 2016, in the intensive apple orchard founded near the village of Păulești, Călărași district, in the autumn of 2006 at the company S.R.L."Codru ST". The trees of the Idared variety grafted on the M9 rootstock were used as the object of study. The crown after which the trees were trained was super spindle. Plant spacing is 3.5 x 1.2 m.

The design of the experiment to determine the efficacy of the growth regulator Obsthormon 24a (NAA 75g/l) for the prevention of drop during pre-harvest and harvest of fruit included the following variants: V1- Without treatment (control); V2 - Obsthormon 24a, 200 ml/ha; V3 - Obsthormon 24a, 300 ml/ha; V4 - Obsthormon 24a, 400 ml/ha; V5 - Obsthormon 24a, 500 ml/ha; V6 - Obsthormon 24a, 200+200 ml/ha; V7 - Obsthormon 24a, 200 +300 ml/ha.

On the experimental sector, according to the experimental design, no intervention was carried out on the trees in variant one. In variants two to five, one treatment with Obsthormon 24a was carried out with 15 days until harvest (20.09.2016). In variants six and seven, two treatments with Obsthormon 24a were carried out, the first one on 04.07.2016 and the next one with 15 days until harvest (20.09.2016).

The plots were laid out in blocks, each variant having 4 repetitions. Each repetition consisted of 7 trees. At the boundaries between plots and experimental replicates, 1 tree was left untreated to avoid overlapping of variants or replicates during treatments.

Tree treatments were carried out with the hand-held sprayer during the morning windless hours. The amount of solution per tree was 0.42 litres, based on the number of trees per unit area and the recommended water quantity of 1000 l/ha.

The soil was kept as grass ground cover on the intervals between the rows and herbicided on the strips between the trees in rows 1.2 m wide. Drip irrigation was used.

The research was carried out under field and laboratory conditions following accepted methods of carrying out experiments on fruit crops with growth regulators.

Records for determining the amount of fruit fallen under the tree and those harvested from the crown were made during the harvest period.

Evaluation of the firmness of the apples was carried out using the FT 327 penetrometer, which determines the resistance of the pulp to the penetration of a plunger with a surface area of 1 cm^2. Ten fruits were picked from each tree, in the equatorial zone from two exactly opposite sides, a disc with an area of about 2 cm^2 was cut from the apple skin. Then using the penetrometer for each lot, 10 firmness evaluations were made, and the average was recorded.

The chemical composition of the fruit was assessed by soluble matter content using the portable refractometer 53000C.

The results were reported to the control variety.

Results and Discussion

Pre-harvest fruit drop is genetic, but it is also due to poor ecological and technological conditions. In some apple varieties, 2-3 weeks before harvest, intense fruit drop occurs due to the appearance of a layer of separating suber in the insertion zone of the branch stalk. Control of premature fruit drop by hormone treatments is a modern technological procedure to maintain fruit production within the tree crown and increase the economic efficiency of apple production.

The fruit of Idared is characterized by a higher average weight, a short peduncle and more pronounced pre-harvest fruit drop compared to other varieties.

NAA is a synthetic plant growth regulator that slows apple drop within two weeks of treatment, and repeated applications are more effective than a single treatment.

The investigations carried out (Table 1) show that the overall yield for the variants studied did not differ substantially between them, ranging from 41.91 t/ha for Obsthormon 24a at 500 ml/ha to 43.43 t/ha for Obsthormon 24a at 300 ml/ha. Treatment of trees with 1-naphthylacetic acid optimized the hormonal activity within the crown, decreasing the amount of premature fruit drop. If, for example, under the crown of the trees of the control variant, a production of 9.88 t/ha of apples was collected from the ground, then following treatment with the growth regulator Obsthormon 24a, the indices in the study registered values from 0.81 to 3.90 t/ha, i.e. the share of fallen production was 23.1% and 1.9 - 9.1% respectively.

Table 1

Influence of the growth regulator Obsthormon 24a on fruit yield per unit area of Idared at harvest

Variants of the experiment	Yield, t/ha			Share of fallen production, %
	Dropped from the tree	Kept on the tree	Total	
Without treatment (control)	9,88	32,31	42,69	23,1
Obsthormon 24a, 200 ml/ha	3,90	38,95	42,85	9,1
Obsthormon 24a, 300 ml/ha	3,10	40,33	43,43	7,1
Obsthormon 24a, 400 ml/ha	2,00	40,45	42,45	4,7
Obsthormon 24a, 500 ml/ha	1,21	40,74	41,91	2,9
Obsthormon 24a, 200+200 ml/ha	1,19	41,50	42,69	2,8
Obsthormon 24a, 200 +300 ml/ha	0,81	41,69	42,50	1,9
Average	3,16	39,42	42,64	-

The amount of product and the timing of administration had a key influence on the premature drop production within the tree crown. Trees of Obsthormon 24a, 200 ml/ha, had a higher production of prematurely fallen fruit (3.9 t/ha), which was 9.1%. Higher values of fallen fruit production were also recorded in the Obsthormon 24a, 300 ml/ha variants, where it amounted to 3.1 t/ha and 7.1% respectively. In the case of the Obsthormon 24a, 400 ml/ha variant, average values of the index taken in the study were recorded. In the variants Obsthormon 24a, 500 ml/ha, Obsthormon 24a, 200+200 ml/ha and Obsthormon 24a, 200+300 ml/ha the share of prematurely fallen production was 2.9, 2.8 and 1.9 % respectively.
Practically in the above-mentioned variants and the production remaining in the crown of the trees were recorded major values, constituting 40.74, 41.50 and 41.96 t/ha respectively. The rational amount of fruit remaining in the crown was also recorded in the variants Obsthormon 24a, 300 ml/ha (40.33 t/ha) and Obsthormon 24a, 400 ml/ha (40.45 t/ha), which did not decrease substantially compared to the previous variants. Below average yields were obtained when trees were treated with Obsthormon 24a, 200 ml/ha (38.95 t/ha) and the control variant (32.31 t/ha).
The efficiency of performing two separate treatments at different fruit development phenophases showed higher yields collected from the crown of the trees compared to the variants where only one treatment was applied and the one fallen on the ground showed minimal values. In the case of the Obsthormon 24a, 200+200 ml/ha growth regulator treatment, the difference between the yield collected from the crown and the control variant was 8.69 t/ha, while in the Obsthormon 24a, 200+300 ml/ha variant it increased to 9.07 t/ha.
The results obtained show that among the variants with the use of a growth regulator to prevent fruit drop like Obsthormon 24a, more convincing results were obtained in the case of a single treatment with the 500 ml/ha dose, or in two doses with the 200+200 ml/ha and 200+300 ml/ha doses where a more favourable ratio between the quantity of fruit collected from the crown and from the ground was recorded.
The experimental data obtained (Table 2) show that the total number of fruits formed in the crown of Idared apple trees varied during the research period from 105 to 114 fruits. Large deviations between the number of fruits were not recorded. Treatment with 1-naphthylacetic acid (NAA) significantly influenced pre-harvest fruit drop. A more pronounced pre-harvest fruit drop was recorded in the control variant, where the number of fruits collected from the ground was 25 pcs/tree. When trees were treated with the growth regulator Obsthormon 24a, the number of prematurely fallen fruits varied from 2 to 10 pcs/tree.

Table 2

Influence of the growth regulator Obsthormon 24a on the total number of fallen fruit including dynamics in the pre-harvest period in apple trees of the Idared variety

Variants of the experiment	Total number of fruits, pcs/tree	Total number of fallen fruits, pcs/tree	Number of fallen fruits, in dynamics, pcs/tree		
			25.09.2016	30.09.2016	05.10.2016
Without treatment (control)	110	25	4	8	13
Obsthormon 24a, 200 ml/ha	112	10	1	3	6

Obsthormon 24a, 300 ml/ha	114	8	0	2	6
Obsthormon 24a, 400 ml/ha	108	5	0	1	4
Obsthormon 24a, 500 ml/ha	106	3	0	1	2
Obsthormon 24a, 200+200 ml/ha	111	3	0	1	2
Obsthormon 24a, 200 +300 ml/ha	105	2	0	1	1

The amount of product applied, and the period of treatment significantly influenced the number of prematurely fallen fruits from the crown. More pre-harvest drop was recorded in the variants where the treatment dose was lower. If for example in the Obsthormon 24a variant, 200 ml/ha, the number of prematurely fallen fruit was 10 pcs/tree, then when increasing the amount of product to 300 ml/ha it was 8 pcs/tree.A more evident decrease in the number of prematurely fallen fruit after treatment with Obsthormon 24a was obtained in the variants where 400-500 ml/ha of product were applied. In these variants we recorded a pre-harvest fruit drop of 2 to 5 pcs/tree.

This is explained by the fact that the trees received a higher amount of auxin, which is more rationally distributed within the crown, the connection of the stem peduncle with the fruit formations are firmer, elastic and there is no formation of suber layer in that area.A lower number of prematurely fallen fruit was recorded in Obsthormon 24a, 500 ml/ha, (3 pcs/tree), Obsthormon 24a, 200+200 ml/ha (3 pcs/tree) and Obsthormon 24a, 200 + 300 ml/ha (2 pcs/tree). Since the dose used in each treatment is lower when Obsthormon 24a is applied in two doses, the final effect is the same as for Obsthormon 24a at the 500 ml/ha dose.

Treating trees with 1-naphthylacetic acid influences the period of pre-harvest fruit drop. If in the control variant 4 fallen fruits were recorded in the first 5 days, then in the following 5 days this indicator recorded values of 8 pcs/tree. A higher share of prematurely fallen fruit in the variant was scored in the period 30.09 - 05.10.2016, which amounted to 13 pcs/tree. Treatment with Obsthormon 24a product in the dose 200 ml/ha decreased pre-harvest fruit drop in the dynamics, constituting 1; 3 and 6 pcs/tree, respectively.

Increasing the amount of product applied per unit area decreases the share of pre-harvest fruit drop from the tree crown, with a more rational redistribution of fruit in Obsthormon 24a, 500 ml/ha, Obsthormon 24a, 200+200 ml/ha and Obsthormon 24a, 200+300 ml/ha.Orchardists should take into consideration that when implementing modern technological elements, the focus should not only be on increasing the fruit production of the plantation, but also on the quality of the fruit (firmness, soluble substances, etc.), or at least not to reduce it.Within the investigated variants (Figure 1) we record that the flesh firmness of Idared apple fruits 15 days before harvesting was practically identical and amounted to 9.2-9.5 kg/cm^2.

During the harvesting period the flesh firmness of the fruit of the studied variants decreased to 7.2-7.8 kg/cm^2. Among the variants studied, a higher firmness during the period was obtained in the control variant, without treatment - 7.8 kg/cm^2. In the case of the variants treated with the growth regulator Obsthormon 24a, there was a decrease in the index in the study, ranging from 7.2 to 7.6 kg/cm^2. Lower values of flesh firmness in the investigated apples were obtained in the variants Obsthormon 24a, 500 ml/ha and Obsthormon 24a, 400 ml/ha, where the index in the study constituted 7.2 and 7.3 kg/cm^2 respectively. In the other variants treated with the growth regulator Obsthormon 24a, in different doses and batches we recorded average values of flesh firmness of Idared apple fruits (7.5 - 7.6 kg/cm^2).

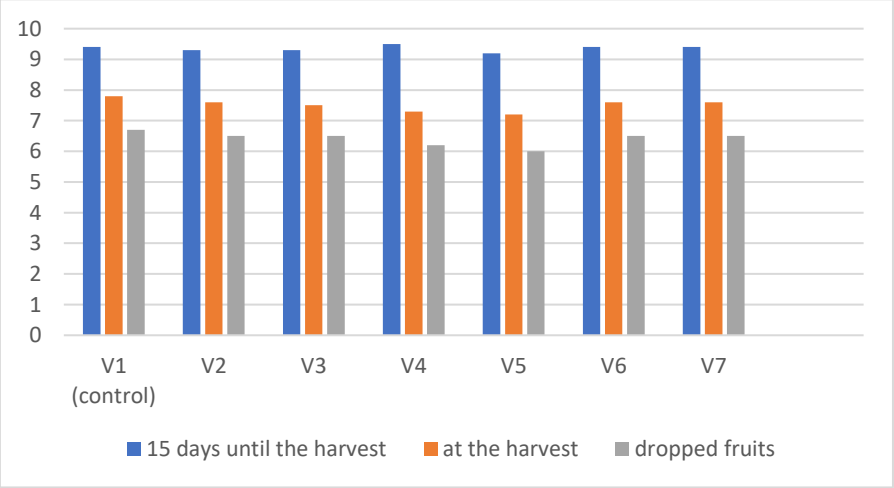

Figure 1. Influence of the growth regulator Obsthormon 24a on the flesh firmness of Idared apple

fruits, kg/cm^2

The above-mentioned legality is also valid for the values obtained from fruit falling to the ground under the crown of the trees. This shows that the growth regulator Obsthormon 24a, whose active substance is NAA, favours to a certain extent the physiological processes occurring in the fruit, i.e. it slightly increases the degree of ethylene formation, thus slightly accelerating fruit ripening.
Fruit that has fallen to the ground from the crown of the tree is much less firm compared to that from the crown of the tree. On the variants under study the fruit firmness varied between 6.0-6.7 kg/cm^2. Thus, the difference in the firmness of fruit fallen on the ground and those collected from the tree crown was 1.1-1.2 kg/cm^2. The highest value of the mentioned index was recorded in Obsthormon 24a, 500 ml/ha - 1.2 kg/cm^2. The other variants treated with the growth regulator Obsthormon 24a showed differences in firmness at the level of the control variant, which was 1.1 kg/cm^2.
The obtained data also show that the amount of soluble substance of the fruit in the Idared variety on the variants under study was 12.7 - 13.5% (Figure 2).

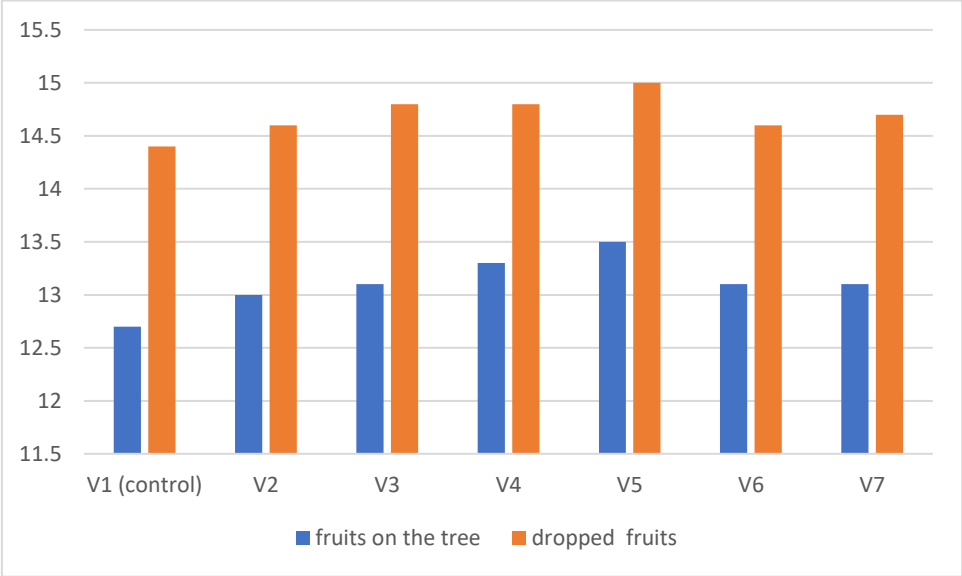

Figure 2. Influence of the growth regulator Obsthormon 24a on the soluble matter content of Idared apple fruits, %

The lowest value of soluble substance weight was obtained in the control version, without treatment - 12.7%. In the case of treatment with the growth regulator Obsthormon 24a, we recorded an increase of 0.3-0.8% of the index in the study compared to the control variant, constituting 13.0-13.5%. This fact shows us that the growth regulator Obsthormon 24a has reduced the firmness of the fruit and increased the amount of soluble substance.
The fruit fallen on the ground from the crown of the trees have a lower firmness and an increased content of soluble dry matter, constituting on the variants under study 14.4 - 15.0%. This amount of soluble solids shows us that the fruit fell on the ground with a higher degree of ripeness and can only be used for processing, not examined for cold storage.

Conclusions

1-Naphthylacetic acid is an auxin that can prevent pre-harvest fruit drop, but at the same time it slightly reduces the firmness of the fruit and increases the amount of soluble substance in the fruit, however this is not an impediment to store them in cold storage.
Higher yields harvested from the crown of Idared apple trees, in relation to fruit quality, were recorded in the variants where two treatments with the growth regulator Obsthormon 24a were applied: the first treatment in the first decade of July, when fruit bud differentiation starts, with the 200 ml/ha dose, and the second treatment with the 300 ml/ha dose 15 days before fruit harvest.

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