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UTILIZAREA UNUI SISTEM INTEGRAT DE COMBATERE A BOLILOR ȘI DĂUNĂTORILOR ÎN OBȚINEREA DE MATERIAL SĂDITOR POMICOL DÂMBOVIȚA
USE OF AN INTEGRATED SYSTEM FOR DISEASE AND PEST CONTROL IN THE PRODUCTION OF HIGH-QUALITY APPLE PLANTING MATERIAL

Comănescu Daniel-Nicolae[1], Bolbose Cecilia[1], Petre Gheorghe[1], Mareși Eugenia-Florentina[2]
[1]Research Station for Fruit-Growing Voinești, România
[2]Research Institute for Fruit-Growing Pitești, România

Abstract

The research conducted in the nursery fields focused on the development and implementation of an integrated system for the propagation of fruit tree planting material, through the combined use of genetic control methods by promoting apple cultivars resistant to major diseases-and biotechnical means, including pest monitoring, risk assessment, and the application of biologically effective control products with minimal environmental impact. To ensure an appropriate phytosanitary status for disease-resistant apple cultivars in the nursery fields, the integrated system recommended the application of the following biological treatments: for apple scab, three fungicide treatments based on copper compounds (Bordeaux mixture at 0.5% concentration; Champ 77 WG at 0.2%; Kocide 2000 at 0.3%), due to the emergence of new scab races overcoming the Vf gene resistance, combined with sulfur-based fungicides (Kumulus DF at 0.3%, Thiovit Jet 80 WG at 5-8 kg/ha), applied before and after flowering, and as a final treatment. For powdery mildew control, targeted treatments were also administered in the same critical growth stages. Pest management involved 7–8 applications at forecasted warning times using biological products such as MadexTop (0.001% conc.), Bactospeine DF (0.07% conc.), and Laser 240 SC (0.06% conc.). The integrated disease and pest management system developed for the production of high-quality apple planting material from the "Certified" category also entails the rehabilitation of fruit tree nurseries. These nurseries must supply planting material for establishing orchards intended for organic fruit production, increasingly demanded by consumers, with a positive effect on environmental protection.

Cuvinte cheie: sistem integrat, material de plantare fructifer, soiuri de măr rezistente, portaltoi, produse de combatere biologice.
Key words: integrated system, fruit tree planting material, disease-resistant apple cultivars, rootstock, biological control products.

1. Introduction

Integrated pest control represents a balance between preventive measures and curative interventions, taking into account minimal environmental impact and crop health protection. It is an approach to reduce the dependence on chemical pesticides and contributes to the long-term sustainability of fruit production.

Research carried out in the orchard nurseries of Research Station for Fruit-Growing Voinești and Research Institute for Fruit Growing Pitesti, Mărăcineni contributes to the implementation of innovative, economical, and rational solutions based on the principles of integrated pest control, using genetic and biological means to multiply high-quality apple tree planting material.

Therefore, a promising apple variety must be established, with disease-resistant cultivars designed to produce healthy fruits, with less treatments, which is beneficial to consumers, and mother plantations supplying grafting shoots, must be established within the nursery, in order to obtain "Certified" category fruit tree planting material.

Consequently, there is a need to rehabilitate fruit tree nurseries so that they are capable of producing high-quality fruit tree planting material for propagation and planting of apple trees that meets the needs of apple producers and is adapted to specific soil and climate conditions.

2. Material and methods

Some of the disease-resistant apple cultivars that will be part of the new mother plantation supplying grafted shoots for the production of "Certified" category planting material are being studied in two apple orchards:

- the orchard established in the spring of 2022 with trees in their third year after planting, comprising disease-resistant apple cultivars: 'Real', 'Remar', 'Romus 3', 'Valery', 'Florina', and cultivars requested at planting; 'Jonathan', 'Idared', 'Goldspur', 'Gala', 'Generos', grafted onto 'M9' rootstock, with trees planted at a distance of 3.5 x 1 m (2,857 trees/ha), crown shape, freely flattened on the row of trees;

- the plantation, established in the spring of 2023, with trees in their second year after planting, it includes disease-resistant apple cultivars: 'Cezar', 'Real', 'Valery', 'Remar', 'Inedit', 'Luca', 'Iris', 'Brumar', grafted onto 'M9' rootstock, with trees planted at a distance of 3.0 x 1 m (3,333 trees/ha), crown shape, freely flattened on the row of trees.

In both apple orchards, the phenophases of flowering, growth vigour, yield, and fruit quality were recorded.

In order to establish the principles of integrated pest control in obtaining high-quality apple planting material, research was carried out by observing the mother plantation of grafted shoots, disease-resistant apple cultivars in apple orchards with 2-3-year-old trees, and apple rootstocks in the nursery fields.

A set of ecological and biochemical methods were used to control pests and diseases, as well as to test biological products to minimize the negative impact on the environment and improve plant health. Pheromone attractants specific to each pest were used to monitor pest species, and the effectiveness of the products applied were assessed through repeated observations of leaves, sprouts, and fruit.

3. **Results and discussions**

Evaluation of disease-resistant apple cultivars for promotion in the mother plantation supplying grafting shoots

The apple cultivars that make up the current assortment require the application of a significant number of chemical treatments, which lead to high production costs and expensive technologies, as well as environmental pollution at the soil and plant level, with negative effects on the agrobiocenotic balance of the orchard. Modernizing the current apple assortment by approving and expanding the cultivation of disease-resistant cultivars contributes to obtaining less polluted fruit, which is increasingly in demand by consumers. At the same time, it allows for the development of economical and ecological technological sequences, based on an integrated pest management strategy, with positive effects on environmental protection.

Phenological phases of fruit-bearing organs

In 2024, climatic conditions differed from previous years, especially in March, when maximum daily temperatures frequently exceeded 16-17^{0}C, reaching over 21^{0}C in the last ten days and continuing above 20^{0}C, favouring the rapid development of the phenophases of apple fruit buds, so that the first flowers opened in the first ten days of April, about two weeks earlier than in previous years.

The recorded data show that, in the three-year-old trees in the apple orchard established in 2022, the first flowers opened on the 'Romus 3' cultivar (08.04), followed by the 'Valery' cultivar and 2-3 days later by the other cultivars, including those susceptible to disease, in the same plot (08-11.04).

For disease-resistant apple cultivars, with trees in their second year after planting, located in another location, flowering began two days later for the same cultivars ('Real', 'Remar', 'Valery', April 10-12). However, for early-flowering cultivars, namely Iris, the first flowers opened on 6 April, followed 1-2 days later by the 'Luca' and 'Brumar' cultivars and 3-5 days later by the other cultivars (10-12 April). Mass flowering in both plots was recorded 3-4 days after the first flowers opened.

Due to maximum daily temperatures of 23-26^{0}C recorded in the first ten days of April and thereafter, flowering lasted 10-14 days, ending towards the end of the second ten days (April 19-20) in the orchard with trees in their third year after planting and in the first days of the third decade (April 21-24), in the orchard with trees in their second year after planting, a period when flowering usually begins in most years.

In both plots, the apple cultivars had conditions for proper fruit setting, depending on the degree of flowering, rated 3-4 and 5.

It is estimated that the disease-resistant and disease-sensitive apple cultivars required for planting overlap partially or totally during flowering, making it possible to group them in a single plot for mutual pollination.

Vegetative growth of trees, production potential, and fruit quality parameters

Vegetative growth of trees

The vigour of the apple tree cultivars studied is expressed quantitatively by the volume of vegetative growth accumulated annually through trunk dimensions, which depends on the vigour of the cultivars, combined with soil fertility, planting distance etc., the unchanging factor being the rootstock.

The increase in diameter of the trunk at 30 cm above ground level, the production potential, and the fruit quality parameters for the apple cultivars studied are presented in Table 1.

Depending on the growth in diameter of the tree trunks, in both plots cultivated with apples, 2-3 years after planting, the apple cultivars studied, cultivated in a high-density system, grafted onto M.9 rootstock, show different values depending on the vigour of the cultivar.

In the apple orchard, established in 2022, with 3-year-old trees, the most vigorous apple cultivars with disease resistance proved to be 'Florina', 'Valery', 'Romus 3', and 'Remar', with trunk diameters ranging from 24.0 to 27.6 mm, followed by the Real cultivar with a value of 20.0 mm and a trunk growth increase of 2.2-3.6 mm.

In the apple orchard, with trees in their second year after planting, the most vigorous disease-resistant apple cultivars are: 'Cezar', 'Real', 'Remar', 'Valery' with values between 24.0 and 25.6 mm, followed by the other cultivars, namely: 'Inedit', 'Iris', and 'Luca', with values between 20.3 and 23.4 mm, with an average growth rate of 5.1-8.4 mm. The values are higher than for 3-year-old trees, which are smaller due to the significant yields achieved in the third year after planting.

In terms of trunk diameter growth in the apple cultivars studied, the values recorded are suitable for promotion and expansion in high-density orchards and selected to supplement the mother plantation supplying grafted branches from the nursery of Research Station for Fruit-Growing Voinești.

Production potential

One of the priority objectives of the study was to assess production capacity, as this is the most important characteristic in promoting cultivars for cultivation in order to establish new commercial plantations.

The yields obtained as early as 2-3 years after planting demonstrate the outstanding performance of the high-density apple system, which can be extended to established orchard areas, using only the most productive cultivars that provide fruit of a quality that meets market requirements.

In the apple orchard established in 2022, with trees in their third year after planting, the highest yields recorded for disease-resistant apple cultivars were 22.4 t/ha for the 'Valery' variety, followed by 'Romus 3' with 16.7 t/ha and 'Florina' with 14.3 t/ha. The 'Real' and 'Remar' cultivars recorded 10.7-10.8 t/ha

In the apple orchard established in 2023, with trees in their second year after planting, using only disease-resistant cultivars, the highest yields were recorded for the following cultivars: 'Real' (9.6 t/ha). 'Inedit' (7.7 t/ha), 'Brumar' (7.2 t/ha), 'Valery' (6.7 t/ha), 'Luca' (6.4 t/ha), and 'Remar' (6.1 t/ha).

High-density tree cultivation, using disease-resistant apple cultivars, creates the conditions for the development of modern fruit growing in established fruit-growing areas, with new technological solutions adapted to the conditions in our country.

Fruit quality parameters

The study conducted on disease-resistant apple cultivars grafted onto M.9 rootstock and grown in a high-density system reveals genetic variability in fruit size.

In the apple orchard, with trees in their third year after planting, with disease-resistant apple cultivars, the fruit weight was 150 g/fruit for the 'Romus 3' cultivar, with smaller fruits, and 170-180 g/fruit for the other cultivars; 'Real' and 'Valery' with 170 g/fruit; 'Remar' and 'Florina' with 180 g/fruit. In 2-year-old trees, most cultivars produced larger fruits, weighing 170-190 g/fruit, with fewer fruits in trees in their second year after planting. In terms of quality parameters, firmness and dry matter content, different values are recorded depending on the variety.

In early-maturing cultivars, fruit pulp firmness ranged from 9.2 to 9.7 kgf/cm^2, while in most autumn-winter maturing apple cultivars, pulp firmness ranged from 10.4 to 12.5 kgf/cm^2. The dry matter content remained within the range of 12.5 to 15.8%, with the highest amount being accumulated by the Valery variety (15.7-15.8%).

Analysis of rootstock types, regarding their ability to sprout and take root in the layering bed.

The SCDP Voinești nursery has a layering bed in the *Base* category with the following rootstock types: 'M9 T337' with 1900 pieces; 'MM 106' with 4000 pieces; 'M 26' with 1600 pieces, a total of 7,500 pieces planted in 2014, purchased from Italy, from “Centro Attivita Vivaistiche”. The rootstock types are at full production potential, ensuring the necessary vegetative rootstock for grafting in field II and the production of grafted apple trees in the SCDP Voinești nursery, with a surplus available for other nurseries in the country.

In 2024, virological tests performed using the ELISA test confirmed the absence of specific viruses.

Under the climatic conditions of 2024, the three types of rootstocks from the layering bed established in 2014, in the *Base* category, vegetated appropriately, ensuring quality layers for the production of fruit tree planting material in the *Certified* category.

The number of cuttings/bush, their vigour, and the evaluation of cutting production are presented in Table 2.

The data presented shows an average number of 18 cuttings/bush for the 'MM 106' rootstock, followed by 'M 26' with 15 cuttings/bush and 14 cuttings for 'M 9 T 337'. The average length of the cuttings is 120 cm for the 'MM 106' rootstock, which is more vigorous, compared to 'M 26', which has an average height of 105 cm, and 90 cm for the 'M 9 T 337' rootstock, which is the least vigorous, specific for grafting apple cultivars suitable for establishing high-density orchards.

In 2024, a total of 122,600 cuttings were produced, of which: 72,000 'MM 106', 26,600 'M 9 T 337', and 24,000 'M 26', sufficient to meet the cutting requirements for the establishment of Field I in the spring of 2025, with a surplus of cuttings to be sold to nurseries in the country, including private nurseries and even nurseries belonging to research units, with certificates of authenticity and quality being issued.

At Research Institute for Fruit Growing Pitesti, Mărăcineni, the propagation of apple rootstocks is done by layering and applying dry and green cuttings.

For the propagation of vegetative apple rootstocks by green cuttings, research in this phase was carried out at the beginning of June (08.06.2024), on two variants: the variant with Radistim rooting biostimulator and the control variant without rooting biostimulators. The cuttings in the herbaceous stage were fragmented into 25 cm long portions with 3-4 normally developed leaves, and their rooting was done on a rooting substrate composed of washed river sand (Figures 1 and 2).

The cuttings are taken in autumn, when the root is mature (brown in colour), stored in stratification over winter, and planted in the training field in the spring of the following year. Observations made during this phase regarding green cuttings showed that the variant using the Radistim biostimulator on both rootstocks had the best results (Table 3) (Figures 3 and 4).

When propagating by cutting, the budding capacity was evaluated on three bushes from each rootstock. The 'MM 106' rootstock had the highest number of cuttings per bush (9 cuttings/bush), compared to the 'M 9' rootstock, which had fewer cuttings per bush but of greater length (83.53 cm).

Development of an integrated system for controlling diseases and pests in obtaining high-quality apple planting material by testing biological products with a positive effect in significantly reducing the negative impact on the environment.

Integrated control represents a balance between preventive measures and curative interventions, taking into account the minimal impact on the environment and the protection of crop health.

It is an approach that reduces dependence on chemical pesticides and contributes to the long-term sustainability of fruit production.

The effectiveness of biological products in combating diseases and pests:

Due to the emergence of new races of apple scab which overcome the resistance provided by the Vf gene, it is necessary to apply three treatments for scab, combined with sulfur-based fungicides for powdery mildew. These treatments are applied before and after flowering and at the last treatment, using biological products.

After testing products for scab on disease-resistant apple cultivars, the following copper-based fungicides are recommended: Bordeaux mixture at 0.5% concentration; Champ 77 WG at 0.2% concentration; Kocide 2000 at 0.3% concentration, combined with sulfur-based fungicides: Kumulus DF at 0.3% concentration, Thiovit Jet 80 WG, dose 5-8 kg/ha, for powdery mildew.

The biology of the main pest species (apple worms, aphids, leaf miners, mites, San José scale) was monitored throughout the growing season (March-September), correlating the biological reserve determined with climatic factors and the variety of cultivars in the crop, tracking critical moments in the life cycle, the numerical density of the pest population, the maximum flight curve, and the beginning of egg laying. By using pheromones with attractants specific to each pest, the EIL (economic injury level) was determined (2.5-3 moths/trap/week).

The tested biological products were applied at the warning stage for each pest species, and the evaluation of the results was expressed in terms of their effectiveness.

To control pests on disease-resistant apple cultivars, 7-8 treatments with biological products are recommended: Madex Top at 0.001% concentration, Bactospeine DF at 0.1% concentration, Laser 240 SC at 0.06% concentration.

Obtaining high-quality apple planting material, by using an integrated disease and pest control system, is achieved by promoting the propagation and planting of disease-resistant apple cultivars, as well as by using products with high biological efficacy and minimal pollution, which ensure rational pest control.

4. Conclusions

In strengthening the capacity to multiply high-quality apple tree planting material, studies and research highlight the following conclusions:

The apple cultivars studied for disease resistance: 'Real', 'Remar', 'Romus 3', 'Valery', 'Cezar', 'Inedit', 'Brumar', 'Florina', performed well in cultivation, demonstrating qualities that make them suitable

for use in mother plantations supplying grafted branches for the production of planting material in the Certified category.

Vegetative rootstock types: 'MM 106', 'M 26', and 'M 9 T 337', in the *Base* category, are at full production potential, ensuring the necessary rootstock for grafting apple planting material in Research Station for Fruit-Growing Voinesti nursery and remain excellent for use in other fruit tree nurseries in Romania.

The use of disease-resistant apple cultivars and nominated rootstock types ensures the production of valuable apple planting material that is guaranteed in terms of authenticity, health, and suitability for the new orchard systems that will be expanded in established fruit-growing areas.

In developing the integrated system for combating diseases and pests in the propagation of high-quality apple planting material, products with high biological efficacy and minimal polluting side effects were tested and recommended, based on ecological principles and careful monitoring of their application in cultivation.

The promotion of disease-resistant apple cultivars, created in Romania or from the global variety, ensures the fruit tree planting material for the requirements of establishing orchards that produce organic fruit, increasingly demanded by consumers, with a positive effect on protecting the environment.

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Tables and figures

Table 1. Trunk diameter growth, production potential, and fruit quality parameters for the apple cultivars studied (Voinești, 2024)

No.	Cultivar/rootstock (mm)	Trunk dimensions (mm)		Yield (t/ha)	Fruit quality parameters		
		Year 2024	Growth rate		Fruit weight (g)	Firmness (kgf/cm^2)	Dry matter (%)
I	**Apple orchard, established in 2022**						
	Disease-resistant cultivars						
1	Real/M.9	20.0	3.6	10.7	170	12.4	13.5
2	Remar/M.9	26.7	3.5	10.8	180	12.0	12.5
3	Romus 3/M.9	24.3	2.2	16.7	150	9.2	12.6
4	Valery/M.9	24.0	2.6	22.3	170	12.3	15.8
5	Florina/M.9	24.7	3.6	14.3	185	11.2	15.0
	Disease-sensitive cultivars, required for planting						
1	Jonathan/M.9	22.0	2.9	5.3	160	12.2	15.2
2	Idared/M.9	19.9	2.3	4.3	190	10.6	13.6
3	Goldspur/M.9	19.5	1.7	6.6	165	12.5	14.6
4	Gala/M.9	22.2	3.8	3.0	150	12.3	14.5
5	Generos/M.9	23.9	4.5	2.8	180	12.0	12.5
II	**Apple orchard, established in 2023**						
1	Cezar/M.9	25.0	8.1	1.2	180	10.4	14.0
2	Real/M.9	25.6	8.3	9.6	170	11.0	12.8
3	Valery/M.9	24.0	8.2	6.7	175	12.2	15.7
4	Remar/M.9	24.1	8.3	6.1	190	9.7	14.8
5	Inedit/M.9	21.0	6.6	7.7	165	12.2	13.9
6	Luca/M.9	23.4	5.1	6.4	175	10.4	13.4
7	Iris/M.9	20.3	5.4	4.8	160	9.6	13.0
8	Brumar/M.9	24.5	8.4	7.2	180	9.2	14.7

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Table 2. Number of cuttings, average length, and estimated production in the nursery in the *Base* category

No.	Name	No. of cuttings	Average number of cuttings/bush	Average length of cuttings (cm)	Estimated yield
1	MM 106	4,000	18	120	72,000
2	M 9T 337	1,900	14	90	26,600
3	M 26	1,600	15	105	24,000
	Total	7,500	x	x	122,600

Table 3. Evaluation of rooting capacity in green cuttings of apple rootstocks (2024, Mărăcineni)

Rootstock	Variety	Total number of cuttings	Number of rooted cuttings	Rooting percentage
MM 106	Radistim	100	55	55
	Control	100	30	30
M9	Radistim	100	57	57
	Control	100	33	33

Fig. 1. 'MM106' rootstock (green grafting)

Fig. 2. 'M 9' rootstock (green grafting)

Fig. 3. 'MM106' rootstock (rooted cuttings)

Fig. 4. 'M 9' rootstock (rooted cuttings)