STUDY ON THE PRODUCTION OF GRAFTED VINE CUTTINGS USING TWO PLANTING VARIANTS IN THE VINE SCHOOL AND THEIR EFFICIENCY

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Abstract. *Dry grafting on the table is the most used method for vegetative propagation of vines. During the period 2021-2023, 48,000 vines of the Fetească Regală 21 Bl variety were grafted at the Murfatlar Research Station. After grafting, the cuttings were paraffined, stratified, then forced. After forcing, the vines were acclimatized and prepared for planting in the vine school. The percentage of the grafted vines resulting from forcing and good for planting was between 90-95 %. Half of the grafted vines were planted on soil ridge covered with black mulch foil, and half planted on the soil ridge but uncovered. Thus, the yield of the vines and the economic efficiency of each variant could be observed. The grafted cuttings were harvested from the vine school in November, and the yield was 35.66%for the variant planted on the soil ridge covered with mulch foil and 34.33% for the variant planted uncovered. The difference is insignificant and we can say that the planting method did not influence the yield of the grafted vines*

Keywords: grafting, paraffinization, forcing, young shoot, yield

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1. Introduction

As global demand for dairy products rises, farms are pressured to increase milk

When phylloxera appeared in Romania (1880 in Arad and 1884 in Chiţorani-Prahova), there were profound changes in the technology of vine culture and finally it was considered that the best method to fight it is to graft European vines on American vines resistant to this pest [1, 6].

To establish new vine plantations, or to fill gaps in existing plantations, it is necessary to have quality vine planting material, in accordance with the vine legislation and standards in force [7, 8]

Grafted vines are produced in viticultural nurseries, which are units/farms specialized in the production of grafted vines or vines on their own roots. The

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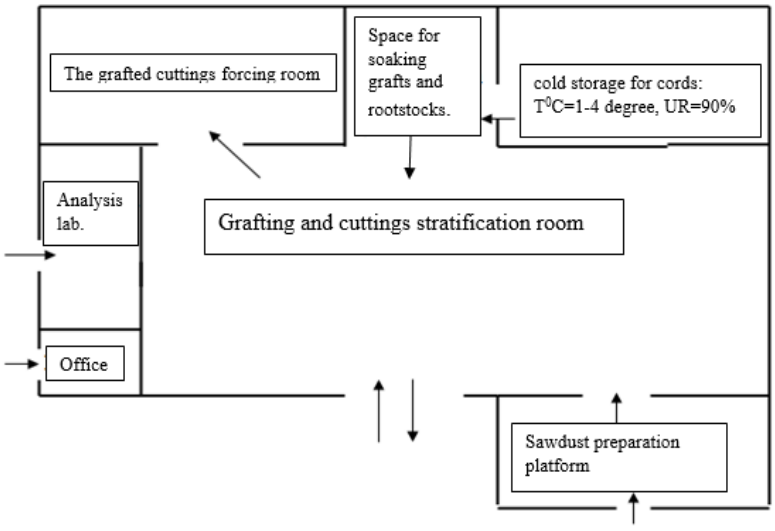
latter are used for establishing vine plantations on sandy soils, where the insect called Phylloxera vastatrix does not live [2, 4].

Currently, the grafting of Vitis vinifera species on rootstocks of American origin is the main method of producing viticultural planting material and fighting against phylloxera [5].

The size of the vine nursery is determined depending on the size of the vine school, respectively the amount of vine planting material that is produced annually. Thus, for one hectare of vine school (with 140 000 grafted vines) are necessary: two hectares of rootstock plantation and three hectars of plantation supplying grafting shoots [3].

The study was carried out within Murfatlar Viti-Vinicol Research Station, which owns: - a vines school, with the land related to the necessary rotation, of 5 hectares; - a plantation of 10 hectares of rootstocks with the Oppenheim SO4-4 clone selection; - several plantations supplying graft cords from different varieties (e.g. Pinot Noir, Pinot Gris; Muscat Ottonel, Fetească Black, Fetească Regală 21 Bl and so on); - a grafting and forcing complex (scheme 1); - climate-controlled cold storage for storing packages of graft and rootstock cords until they are used for grafting.



Scheme 1. Scheme of the grafting and forcing complex

During the period 2021-2023, a total of 48,000 cuttings were grafted from the Fetească Regală 21 Bl variety, which after forcing and acclimatization were planted in the vine school. Half of the grafted vines were planted on ridges covered with black mulch foil, and the rest were also planted on the land with ridges, but uncovered with mulch foil.

2. Materials and methods

2.1 Working material. This was represented by the Fetească Regală variety clone 21 Blaj and by the Berlandieri x Riparia Oppenheim Selectia 4 (SO4-4) rootstock.

Fetească Regală 21 Bl variety (Fig. 1a), is found in the plantation in the Murfatlar Viti-Vinicole Research Station on an area of 1 hectare. Plantation characteristics: - the distance between rows is 2.2 m and between plants per row is 1.1 m; - the area of a vine nutrition is 2.42 m^2; the vine number/hectare: 4,132; -row orientation: N-S; -support system: concrete trellis; -number of wires: 6 of which: one row of double cordon wires and two other rows of wires for shoots directing; trunk highness: semi-tall with 70 cm; driving form: double Guyot. The rootstock SO_{4-4} is led on a single-plane vertical trellis support system with oblique wires, with recommended distances of 2.20 m between rows and 2.00 between vines per row (Fig 1b).

Fig. 1. The vine variety and the rootstock in plantation (original)
a. Fetească Regală 21 Bl variety **b.** The rootstock SO_{4-4}

The harvesting of the rootstock shoots was carried out after the last leaves have fallen and after at least a frost of, -5^0; -6^0 C has passed over them, because their wood, must be well matured. At harvest, the shoots were 6-8 m long. At the grafting complex, after cuting the immature tips and tendrils, the shoots were cut to one length (40 cm), two lengths (80 cm) and three lengths (120 cm), then they were collected in packages of 100 pieces, provided with a label which is written the variety of the rootstock, the date of harvesting and the supplying unit (Fig. 2 a).

The graft shoots were harvested, from the Fetească regală 21 Bl fruit plantation, from the Viti-Vinicol Murfatlar Station. They were harvested immediately after the leaves fall and before frosts, which could affect the viability of the buds. According to the STAS in force (220/5-77) [9], the graft shoots must have at least 8 perfectly healthy buds and a thickness of 7-12 mm. Like the rootstock shoots,

they are stored until grafting (Fig. 2b), but not before being treated with an anticryptogamic agent named chinosol.

Fig. 2. Shoots stored at controlled temperature and humidity (original)
a. rootstock shoots SO4-4 of 3 lengths (120 cm) **b.** graft shoots of Fetească Regală 21 Bl

2.2. The study methods used were:

Observation. Were carried out the following observations:
- on the health of the shoots, directly in the plantations;
- on the correct harvesting and cuting of the shoots of the grafts and rootstocks;
- on the conditions for forcing the grafted cuttings verification;
- on the growth of the shoots from the graft, the roots and the correct formation of the callus.

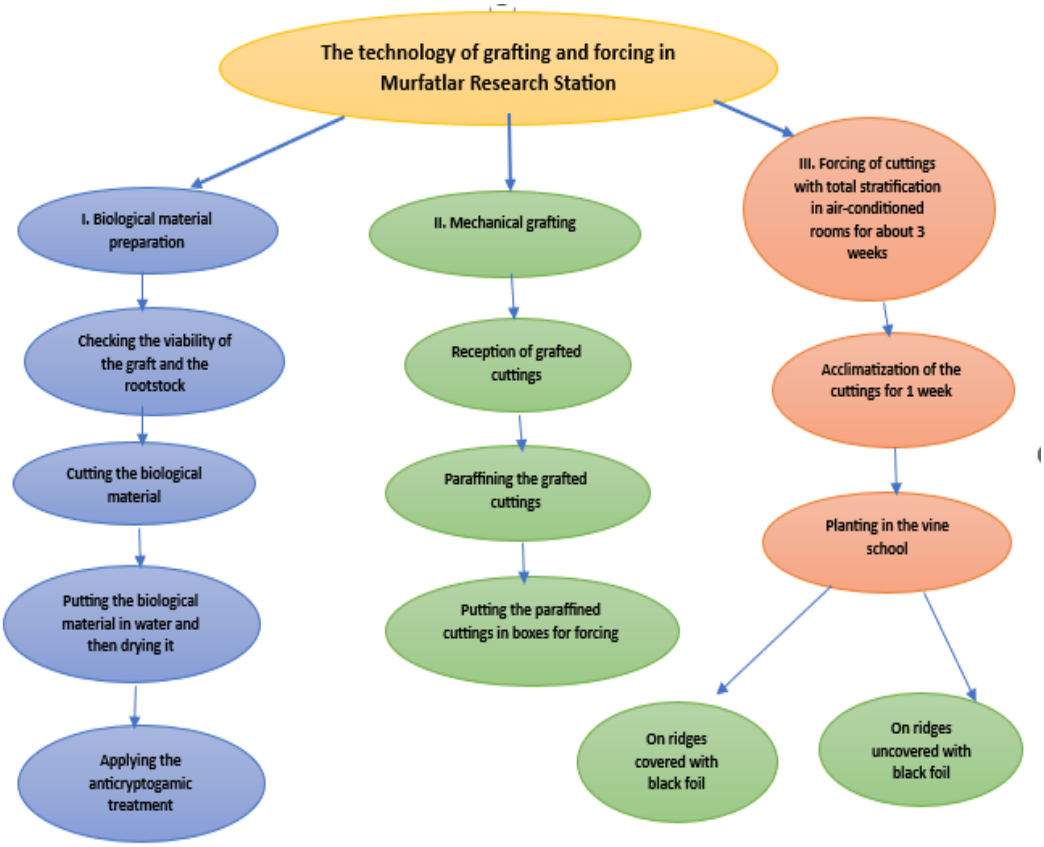
Laboratory determinations. The following were determined:
- macroscopically, the viability of the shoots;
- and microscopically, the viability of the buds from the winter eyes**.**

During and after grafting, the following was carried out:
- verification of the correctness of the omega sectioning and the joining between the partners.

In the vine school, the following was monitored: - the correctness of the planting of the grafted cuttings by the two variants; - the yield of STAS vines, after harvesting - and the economic efficiency of the two variants.

2.3. The technology of grafting, forcing and planting in the school of vines

In Murfatlar Research Station, grafted vines are produced in the grafting and forcing complex and are fortified in the vine school (scheme 2).



Scheme 2. The grafting technology, forcing and planting in the school of vines (original)

The three major stages of grafting technology are: I.- biological material preparation; II- grafting to the table; III-grafted cuttings forcing with total stratification, in coniferous sawdust in forcing rooms, followed by planting the grafted cuttings in the vine school, for a period of vegetation.

3. Results obtained and discussions

3.1. Biological material preparation (graft and rootstock) for grafting

Checking the viability of the graft and rootstock shoots and winter eyes (for graft only), are presented in the Figure 3 a; 3 b and 3 c. The main bud into the winter eyes will generate the future shoot. The shoots and buds into the winter eyes were green, so they were alive.

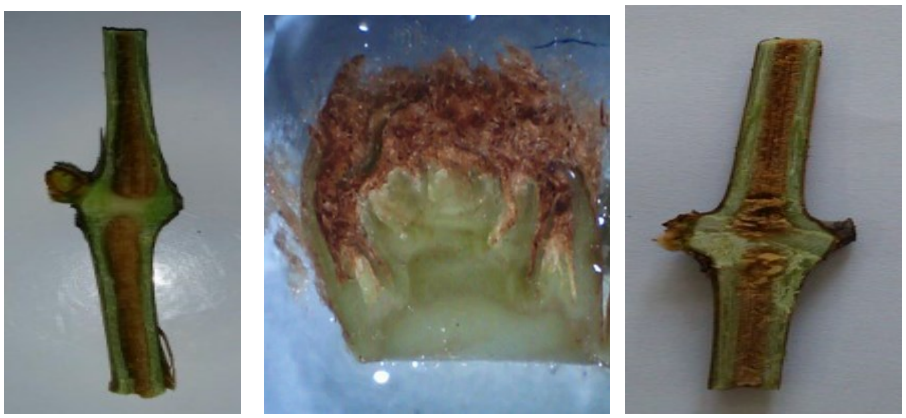


Fig. 3. Viability of the shoot and the winter bud of Fetească Regală 21 Bl variety and the viability of the SO4-4 rootstock (original)
a and **b.** Living shoot and the winter bud of Fetească Regală **c.** SO4-4 rootstock viability 21 Bl variety

Shaping the rootstock and graft cuttings

At the rootstock, the section from the base is refreshed 0.5 cm below the node, after which the shoots of 3 or 2 lengths are segmented to a STAS length, i.e. 40±2 cm, with a diameter of between 7-12 mm (Fig. 4 a). In the same time, the eyes on the length of the cutting are blinded (Fig. 4 b).

Fig. 4. Rootstock cuttings of the SO_{4-4} variety
a. cuttings of a length **b.** blindness of the eyes (original)

The graft shoots, are fragmented starting from the base, into pieces of one eye and one internode. Before grafting, the graft and rootstock are placed in clean water with a low content of limestone and mineral salts, to replenish the lost umidity during storage. The rootstock are kept in water for 48-72 hours, and the graft between 24-48 hours. The preparation of the material was carried out every year during the study period between 27.01.-9.03.

3.2. Mechanical grafting

The grafting of the vines was carried out between 16.03-31.03. of each year, with grafting machines equipped with knives that have a Ω section (Fig. 5 a; b; c).

Fig. 5. Grafting cuttings on the grafting machine (original)
a. sectioning the cuttings **b.** section in Ω **c.** the grafted cutting

After grafting, the quantitative (by counting) and qualitative *reception of the grafted vines* was carried out; it is checked if the position of the graft is correct, if the joint between the two partners is secure and stable and if the diameter of the graft and rootstock are appropriate.

Paraffining the grafted cuttings. The cuttings are introduced with the grafted side, first into water, then shaken to dry and introduced into hot paraffin at 80-82°C and again into cold water. Paraffin treatment (Fig 6 a) aims to avoid dehydration of the partners and protect against pathogens.

Stratification of grafted cuttings for forcing. The grafted cuttings are stratified in boxes with wet sawdust (70-80%) of conifers and disinfected with fungicide. The number of cuttings in a box is 2,000-3,000 pieces, depending on the size of the box. On each box there is a label on which is written: box number; grafts and rootstock variety; number of grafted vines in the box and the date when it was introduced into the forcing chamber (Fig. 6 b)

Fig. 6. Paraffining and stratification of grafted cuttings (original)
a. paraffining **b**. total stratification in sawdust

3.3. Forcing grafted cuttings

Forcing is the process by which artificially created environmental factors such as temperature, humidity, aeration and light act on the grafted vines, so that the grafted vines pass from the state of rest to the state of active life, to form callus, to

glue the graft with the rootstock, and to start the shoot from the graft and the roots from the rootstock (Fig 7 a; b).

Fig 7. Boxes with grafted cuttings in the forcing room (original)
a. boxes with unforced cuttings **b.** boxes with forced cuttings

The temperature was 28-30°C during the forcing period. Humidity had values between 65-95%, higher in the first 8 days of forcing, when the grafted plants need humidity to form the callus (the tissue that unites the graft and the rootstock) and lower in the last days of forcing to avoid the appearance of mold (Tab. 1).

Tabelul 1. The temperature and humidity during the forcing period

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Temperature°C	10-32							30										
Air humidity %	65-90			90-95				75-85										

During forcing, the *Control of shoots and callus formation* was carried out every two days. Optimal callus formation of sections should be circular and slightly prominent. A good rooting is considered when at least two root primordia appeared. When the callus is pearly-yellow, the shoot starting from the graft eye is 3-5 cm long, green and vigorous, the roots have started to grow, and the base of the cutting is well scarred, the forcing of the cuttings is considered complete (Fig. 8)

Fig. 8. Graded cuttings, with completed forcing (original)

After forcing, the grafted cuttings were acclimatized to the field temperature, sorted, shaped and paraffined to be prepared for planting in the vine school. Forcing took about 18 days, and acclimatization took 7 days. The percentage of vines resulting after forcing was: 95% (2021); 90% (2022) and 93% (2023), of good vines to plant, vines with circular calluses and with the graft eye started in vegetation.

3.4. Planting grafted cuttings in the vine school

The land on which the grafted vines were planted was fertilized with manure (40 t/ha) and opened in the autumn of 2020 to a depth of 50 cm. Next spring the soil was worked twice with a disc harrow, then ridges were made with a ridge-making machine (Fig. 9 a; b; c) which, in a single pass, makes the ridge, stretches the drip irrigation hose, stretches the mulch foil over the ridges and drills it for planting the cuttings.

Fig. 9. Making ridges (original)

a. ridge-making machine **b.** ridges covered with foil and with cuttings planted **c.** ridges uncovered with foil and cuttings in vegetation

The planting of the grafted vines in the school was done during the period 23.04-25.04, of each year of study, they were planted differently to observe the yield of the vines and the economic efficiency of each variant. The planting was done in simple rows at 1 meter distance between them and 8 cm distance between vines in a row, resulting a density of 100,000 grafted vines/hectare.

Works carried out in the vine school

Irrigation

Before and after planting, the vines were irrigated with a water rate of 100 cubic meters/hectare, and during the April-August period, for one hectare with a vine nursery, the irrigation rate was 2,000 cubic meters/hectare.

Plant protection
Among the diseases, grapevine downy mildew (*Plasmopara viticola*) is the one that represents the greatest danger, so in each year of study, 15 treatments with antifungal products with systemic and contact products and 2 foliar fertilizations were made.

The hoeing
During the vegetation period, a number of 5 manual hoes and 5 mechanical hoes were made. In the planting variant with a ridges uncovered with mulching foil, 2 additional manual hoes were required.

Weeds combated
Weeds are fought because they compete with the grafted vines for water and nutrient reserves in the soil and because they create a microclimate favorable to the occurrence of diseases such as downy mildew, powdery mildew and even rot, and tall weeds reduce the effectiveness of treatments if they are allowed to grow larger than the vines.

Marking of the grafted vines that do not belong to the planted variety
The work of identification and elimination of impurities is done with the aim of ensuring a biological material of impeccable purity. It is performed in August and consists of cutting below the grafting point of the grafted and unidentified vines.

3.5 Harvesting the grafted vines from the school, their classification and storage

The vines were harvested in November, after the leaves fall (Fig. 10 a; b; c), they were mechanically dislodged, manually collected, transported to the grafting complex where they were shaped, sorted, paraffined and then collected in packages, labeled and stored in special conditions of temperature and humidity so as to avoid dehydration until the next spring, when will be sold.

Fig. 10. Harvesting the grafted vines from the school in November
a. mechanically dislodged **b.** manually gathered **c.** packages with grafted vines, prepared for storage

In order to be considered of quality, the viticultural planting material must meet certain quality criteria according to Order 1267/2005 [8].
The yield and economic efficiency of each planting variant is presented in Table 2.

Table 2. The yield of grafted vines and the economic efficiency of planting variants

Year	No. of grafted vine (pieces	Yield. after forcing (%)	Planted on ridges	No. of vines planted in school	Vines school area (ha)	No. vines harvested from the school	%	Total expen-ses	Lei spent /piece	Average selling price / piece	Profit	Profit rate %
2021	34,000	95.0	with mulch foil	16,150	0.16	5,652.5	35.0	25,436	4.5	6	8,479	33.3
			without mulch foil	16,150	0.16	5,491	34.0	23,062	4.2	6	98,83.8	43.0
2022	6,000	90.0	with mulch foil	2,700	0.03	1,053	39.0	7,160	6.8	9	2,632.5	37.0
			without mulch foil	2,700	0.03	918	34.0	5,875	6.4	9	2,662.2	45.0
2023	8,000	93.0	with mulch foil	3,720	0.04	1,228	33.0	13,872	11.3	12	859,32	6.0
			without mulch foil	3,720	0.04	1,302	35.0	14,062	10.8	12	1,562.4	11.0

Table 2 shows that during the period 2021-2023, a total of 48,000 cuttings were grafted. Eeach year the number of grafted cuttings was different, depending on the grafting material available. The percentages obtained after forcing were good, between 90-95%. In the remaining cuttings up to 100%, the glueing between partners did not occur and they were eliminated during sorting. The percentage of vines harvested in November, during the period 2021-2023, of the variant planted on ridges covered with mulch foil was on average 35.66%, only slightly higher than the variant planted without foil (34.33%), but we could say, this is insignificant. If we analyze the total expenses, we find that in the variant with covered ridges the expenses were higher than in the variant planted on uncovered ridges. The exception is the year 2023, when the expenses for the variant of cuttings planted on uncovered ridges exceeded the expenses for the variant of cuttings planted on covered ridges by 190 lei. The explanation is that the labor force has become expensive.

Conclusion

(1) This study was carried out between 2021-2023 period to Murfatlar Viti-Vinicol Research Station where we grafted 48,000 cuttings of Feteasca Regală 21 Blaj variety, on american rootstok Selectia Oppenheim SO_{4-4} clone.

(2) The grafted cuttings were forced and the percentages obtained after forcing were good, between 90-95%. The rest of 5-10% the glueing between partners did not occur.

(3) The grafted cuttings were planted in the vine school in two variants: on soil ridge covered with black mulch foil, and on soil ridge but uncovered. Thus, the yield of the vines and the economic efficiency of each variant could be observed.

(4) The grafted cuttings were harvested from the vine school in November, and the yield was 35.66% for the variant planted on the soil ridge covered and 34.33% for the variant planted uncovered. The difference is insignificant and we can say that the planting method did not influence the yield of the grafted vines.

(5) We have analyzed the total expenses and we have found that in the variant with covered ridges the expenses were higher than the variant planted uncovered. However, there was an exception, in the year 2023, when the expenses for the variant of cuttings planted on uncovered ridges exceeded the expenses for the the variant of cuttings planted on covered ridges by 190 lei.

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