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THE ECONOMIC IMPACT OF SUBSTRATE MIXTURE ON THE PRODUCTION OF GRAFTED AND POTTED 'FETEASCĂ REGALĂ' VINES

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Abstract

Grapevine planting producing material is focused to produce healthy and long-lived vines. This study analyzes the strategic choices of a nursery to obtain the best profit rate on grafted and potted vines 'Fetească regală' grape variety grafted on Oppenheim Selection 4 root stock was paraffined 8-chinolinol wax (before callusing), and silver color blue color (after grafting callusing and before planting in pots). The unit cost price was calculated based on total expenses and the yield of grafts obtained in the vine greenhouse nursery. The grafts were potted in three rooting mixtures (BP: forest ground 50% + red peat 30% + river sand 15% + conifer sawdust 5%; RP: forest ground 60% + black peat 25% + river sand 10%+ conifer sawdust 5%; RS: forest ground 70% + river sand 15% + conifer sawdust 15%. Variant RP generated the highest yield of the potted grafted vine with a rate of profit of 174.94%, while variant RS, generated the lowest yield directly related with cost production, and rate of profit (133.34%). The results are useful for the small-to-medium grapevine nurseries to choose the best strategies and to enhance their competitiveness and survive in their activity.

Key words: *'Fetească regală', grafted vines, rooting mixture, black peat, red peat, river sand.*

INTRODUCTION

Given the perennial nature of some horticultural crops (grapes especially), their high establishment costs, variability production in quality and prices, it is important to pay attention to risk management (Pozzan et al., 2012). Grapevines are mainly propagated by vegetative methods from cuttings, from which, more than 80 % are grafted vines (Ollat et al., 2012). In the last years, the global planting producing material and wine industry was transformed from small, traditionally oriented, family-owned enterprises to an industry dominated by multinational corporations (Waite et al., 2018). The individual component of risk management may be affected by price, yield, and product quality (Waite et al., 2015).

Rooting media (chemical and physical characteristics) is an important factor for graft production in the greenhouse and directly affect graft quality and efficiency (Sengel et al., 2012). The rooting substrate must be easy to handle, free of weeds and pathogens, had good water capacity and drainage (Rajkumar et al., 2017). Due to its hydrological, physiochemical and agronomic characteristics, peat is commonly used in the callusing stage after grafting (Aroca et al., 2010; Assunção et al., 2019), but also for rooting in pots or other containers (Corbean et al., 2011). For alternatives to peat utilization and to improve agricultural sustainability of rooting media, vineyard winter pruning, and grape stalks are valorized in nursery greenhouses for grapevine planting material production (Ronga et al., 2019; Popescu et al., 2015). Rooting grafts in pots method had a high degree of intensity and require the complete assurance of the material base, complete and thorough knowledge of the technology, and its correct application. The production of grafted vines in nutritional pots includes a large number of agro technical links and requires a high volume of qualified works, justifying itself economically only in cases where a very valuable biological material is multiplied.

Increasing the market potential for wine and grapes increased the demands for planting materials by the improvement and effective employment of techniques which allow the rapid expansion of propagating stock.

A good planting material, regardless the method use to obtained, begins in the previous year. Carbohydrates are reserve substance stored in the amiloplastele of liberian parenchyma, medullar and wooden, under the form of grains. The content of dosed carbohydrates (soluble sugar and starch) in cuttings is a accurate indicator of laboratory for assessing the degree of maturation of canes (rootstock and scion) (Iliescu et al., 2012). The processes of rooting and callusing are energy-intensive processes that cannot be taken over than through hydrolysis of poliglucid located in reserve rootstock cuttings. Therefore, the material with total carbohydrate content below 12% is rejected from propagating (Iliescu et al., 2012; Corbean, 2011).

The yield obtained is directly influenced by the quality of the biological material used (scions and rootstocks), by the ecological conditions (temperature, humidity, ventilation) of the solarium, by the nutrient substrate for rooting, by the phytosanitary substances, and the rooting stimulants. All these factors have the role of reducing the stress of vines when planting in pots (Cookson et al., 2013; Corbean, 2011).

The soil mixture used for potting must be relaxed to allow carbon dioxide release and oxygen access. The ratio between the gap space and the solid parts of the mixture should be 4:1, as opposed to a soil of the chernozem type (which contain a high percentage of humus), where this ratio is usually 1:1 (Corbean, 2011).

Becker, 1975, shows that pure peat, the yield was 56%, and when pure sand was used, the yield was only 12%. That in the case of cultivating grafted vines in nutrient pots, when using peat and sand mixtures, the yield in good grafted vines to be planted is higher as the percentage of peat is higher.

The vigor of the shoot is very important for obtaining a quality vineyard planting material. This is conditioned by the content in reserve substances of the two partners (Iliescu et al., 2012; Warschefsky et al., 2016), the degree of nutrition of the rooting substrate (Ronga et al., 2019; Popescu et al., 2015) and, the fertilization in the vine school (Bozzolo et al., 2017). In the experience, the foliar and root fertilization were used equal doses and concentrations for the three variants, the influence being only of the soil mixture.

Zamanidis et al., 2013, used for the rooting of grafted vines (Rkatsiteli grafted on rootstocks 5 BB and 101-14) different nutrient substrates: soil, pearlite, sawdust; rice bran + fallow + sand (1: 1: 1); peat + fallow + sand (1: 1: 1); loose soil + fallow + sand (1: 1: 1), the percentages of vines good for planting are satisfactory in all variants.

Potted vines should be planted early enough to benefit from a long growing season rather than suffer from a short one. The season should be sufficiently long for the vine to develop self-supporting root and shoots and develop frost-tolerant wood before the winter season (Mudge et al., 2019). At planting, the root system should fill the pot and have an active shoot tip growth with a good basal caliper.

The main objective of the research was to determine the influence of the three types of soil mixture(black peat, read peat and river sand) on the production of grafted vines for ‘Fetească regală’. Based on economic data, the profitability rate was analyzed for each of the three variants. The results may be useful for the producers to obtain grapevine material with the highest profit rate.

MATERIALS AND METHODS

The experience was established at the Jidvei Company, in Alba County, Romania (46°13′20″N 24°06′41″E, elevation 400 m) during 2018. Jidvei Company it is knownas the main grapevine planting producing material in the country, with 1.5-3 million grafts produce per year (Călugăr et al., 2020). The experiment involved the analysis of the rooting substrate in pots on 'Fetească regală' graft rates and its economic efficiency. 'Fetească regală' is a representative grape variety for Târnave vineyard. In Romania is planted on 17.47% of total surface grapevine planted (Antoce and Călugăru, 2017). Scions cuttings of 'Fetească regală' variety were harvested from mother plantation of graft canes of Jidvei Company during the previous fall. Prior to grafting, the degree of maturation of the graft cords and rootstocks was determined by the carbohydrate content and soluble sugars using the method of the anthrona reagent. By this method, the extraction of soluble sugars is made with 80% volume alcohol solution, the starch with 52% volume perchloric acid solution and then treatment with anthrona ($C_{14}H_{100}$) 0.2% solution. The color intensity obtained (with transparent blue-green color shades) is measured colorimetrically, using UV-VIS spectrophotometer at a wavelength of 620nm (Comsa et al., 2013; Călugăr et al., 2010).

The 'Fetească regală' scions cutting canes of 8 buds were kept till grafting at 2-4°C and 90% humidity in cold rooms. Rootstock canes of Oppenheim Selection 4, clone 762 were imported from France. Rootstock canes were cut at 35 cm and scions at 5 cm (1 bud - 1 cm above bud and 3 cm below bud). Pre-grafting hydration and soaking propagation material (scions and rootstock) were made in tanks containing drench water and captan to reduced pathogens infection. Grafting was made using an omega-cut grafting machine in mid-April. The paraffin used after grafting was the paraffin with 8-chinolinol. Stratification was made with pine sawdust, wetted and disinfected with a concentration of 0.01% CuSO4. Grafts were vertically positioned in wooden boxes walls lined with porous polyethylene film. The exchange of humidity and temperature between inside and outside the box was provided by the polyethylene sheet. The capacity of a box is about 2000 grafts (Corbean, 2011). The boxes, after filling with grafts, were covered with a thin canvas over which was placed a 5 cm layer of wet sawdust. The temperature rose from 10 to 32°C, in the first three days of forcing, then went down to 28-30°C, keeping at this level until the end of the callusing (14th day). Air humidity was rose from 65% to on a high level of 85%, in the first three days. After the beginning of the formation of callus mass at the grafting point, after the 3 - 4 days, air humidity has decreased to 75-80% and remained constant until the end of forcing. The grafts forcing was made without light. During callusing, phytosanitary treatment to avoid the attack of *Botrytis cinerea* and saprophytic fungal species of the genus *Fusarium*. At the end of callusing, grafts were classified in two categories: Category I and inadequate (Council Directive 68/193/EEC). Category I grafts have new well defined and formed formations (callus around grafting point, shoots, roots), measured and appreciated according to Celik et al. (1998) and previously shown by Călugăr et al. (2019). The grafts in Category I were paraffined with a second layer with paraffin containing aluminum particles (silver color) before planting in the nutritive pots. After the second layer of paraffin, 30000 grafts were manually transferred into Fertil pot pressed cardboard (7/9/11 cm). Fertil Pot pots made of pressed cardboard have the property of optimum water retention in the soil mixture and allow the roots to easily penetrate the cardboard casing. The pots were filled with three different soil mixtures from local sources. Each soil mixture variant was 10,000 pots, arranged in a randomized design with 10 replicates/variant. The highest weight of mixing pots was in variant RS, where the percentages of forest ground (70%) and sand (15%) were higher than the variants RP and BP (Table 1).

Table 1. Variants of mixture nutritive substrate

Variant	Forest ground	Red peat	Black peat	River sand	Conifer sawdust	Nutritive pot weight
RP	50%	30%	-	15%	5%	247
BP	60%	-	25	10%	5%	274
RS	70%	-	-	15%	15%	323

Rooting grafts in Fertil Pot were made in a tunnel greenhouse covered with plastic foil of width - 6 m, length 50 m and height 4 m. The pots were put on perforated polyethylene foil on the ground over a drainage layer (5 cm depth) of gravel (0.5-1 cm diameter) and clean river sand. Inside the greenhouse tunnel, was appointed 4 alleys, of 1.2 m width and a passing aisle between alleys of 60 cm width.

The delimitation of the alleys where pots were placed was made of concrete slabs with the square section with the side of 8 cm, which ensures good lateral stability of the alleys (Corbean, 2011). During experience, verification of the irrigation system was made, the verification of the covering sheet, the tracing of the layers on which the pots are placed. To prevent excessive heating inside, they were covered with a protective mesh.

The planting of vines was made in the greenhouse, with the base in the nutritional mixture on a depth of 5-6 cm. After planting, the pots were watered with 15-20 L/m² water to ensure the contact of the grafts with the rooting mixture.

During the rooting period of grafted vines in nutrient pots, the temperature, in the first week after planting was maintained at 25-30°C, then, lowered to 20-22°C. The hygroscopicity of the air remained around 85% during the first two weeks, until the appearance of the first leaves, then lowered to 60%. On hot days, when the humidity of the airdropped below 50%, 2-3 artificial watering systems, of short duration, were made (Corbean, 2011).

The moisture content of the nutrient mixture in the pots was maintained within optimal limits of 28-30% of the weight of the rooting mixture, by repeated watering. Root and foliar fertilization were made with water-soluble fertilizers based on nitrogen, phosphorus, potassium, and with micro-elements.

The control of diseases and pests was carried out by weekly treatments with contact and systemic products. The grafts were classified according to root appearance and root output from the pot, growth vigor of grafted vines - shoot length (cm) and diameter (mm).

Grafted Yield of Potted Vines % = (Number of Grafted vines in First Category/ Number of Grafted Vines planted in Pots) x 100

After 4 weeks in greenhouse, all the shoots started from the rootstocks were removed. The grafts in the pots where the growths of the shoots were at least 20 cm long and with a minimum of 4 mm diameter, were selected to be planted in the vineyard.

Economic efficiency calculations were made on the basis of the technology fiches and material costs provided by the producer. The most important economic indicators were calculated as follows:

Profit per unit = Sell price per unit - Cost price per unit (1)

Total profit = Income from sales - Total production expeses (2)

Profit ratio = Total profit / Total incomes (3)

ANOVA (Analysis of Variance) and LSD (Least Significance Difference) test were used to calculate the significant difference between the variants and the mean of experience of yield grafted grapevine and potted vines. The interaction between variants and mean of experience was evaluated at 95%, 99 % and 99.9 % in order to determine the significance. The statistical interpretation of the results was made using Excell 2010, USA.

RESULTS AND DISCUSSIONS

The degree of wood maturation in rootstocks (carbohydrates content: soluble sugars and starch) is an important indicator, which allows both the assessment of physiological processes during the whole vegetation period and the quality of the initial material used to produce grafts (Iliescu et al., 2011). The quality of the initial material (graft and rootstock) is determined by the agricultural techniques applied.

In the Târnave vineyard, the period of active vegetation of the grapevine is lowering (compared to vineyards in southern Romania) due to low heliothermal resources (Bora et al., 2015; Călugăr et al., 2018).

Tabel 2. The content of total carbohydrates of rootstock and scion cuttings before grafting

Variety	Soluble sugars g %	Starch g%	Total carbohydrates g%
Fetească regală	7.95	6.77	14.72
SO4, clone 762	11.11	3.69	14.80

The determination of carbohydrates is a reliable laboratory indicator for assessing the degree of maturation of rootstock and scion cuttings for grafting. Carbohydrate content studied variants recorded values of 14.72 g% for 'Fetească regală' variety and of 14.80 g % for SO4, clone

762 rootstock (Table 2). According to Hunter et al. (2004) and Iliescu et al. (2012), these content of carbohydrates determined in grafting material ranks in category of sufficiently matured (between 14 to 16 g%). Values over 16 g% carbohydrates is considered good matured grafting material. During hydration, grafted material could loss some carbohydrates, between 0.5 to 1.5 g%, depending on the number of days of hydration (Iliescu et al., 2012).The aspects studied are related to the influence of the type of nutritive mixture, potted graft yield, and production costs with a direct impact on the cost per unit of product, but also on economic efficiency. The management of the process of forcing is aimed at obtaining the highest percentage of grafted vines, in which the two partners joined by grafting are congruent by circular callus, the main bud being started in the vegetation and at the basal pole of the rootstock to present moderate callus, formed around with emerged roots. Obtaining quality grafted vines, as well as a growth vigor, is also influenced by the type of paraffin used. Classification of grafted vines was made in two categories: Category I and inappropriate. Grafted vines form Category I have the new formations well defined and shaped (calus, shoots, roots). As previously shown in our research, the yield of 'Fetească regală' grafts in the Category I was 82.8% (Călugăr et al., 2019). Other studies recorded a higher yield of 90%-92.5% of grafted vines after callusing for Storgozia (local variety) grafted on SO_4 rootstock, testing Aktigref, Rebvaks VF, and Proaktigref (Iliev et al., 2014). Teker et al., 2014 using paraffin (name or other characteristics not mention) obtained the highest graft ratio, after callusing, for Cardinal on 5 BB (80.00%) and Michele Palieri on 1103 P (78.33%).Based on the accounting data, the cost of production for 'Fetească regală' grafts after callusing was reported for one hectare of field nursery (250,000 grafts/hectare).The expenses with the necessary materials in the production technology of grafted vines in nutritional pots and the obtained yields was used to calculate the cost price per unit of the product. Due to the data regarding material expenditure, costs of the biological material, paraffin and labor, but also the yield of quality vines obtained after callusing, the cost per unit was calculated (for grafted vine) as 0.27 euro/graft. The labor cost included the harvest of scions buds from mother scion vine, deposit till mechanized grafting, paraffining, maintenance during callusing, sorting and second paraffining (paraffin with aluminium particle - silver color). The low callusing rate after stratification may cause higher costs of biological material (scion buds and rootstock) (Călugăr et al., 2019).

The 8-quinolinol/Silver color paraffin variant was choosen for rooting in different substrates mixtures due to the highest yield 82.8 % after callusing. Potted vines are grafted and dispatched in the same year. The production of vines in nutritious pots is necessary for the newly established plantations during summer. In Romania, this practice is not frequent, mainly this type of planting material is used to replant dead vines in the young vineyards or sell in garden-center for planting in people yards. The vigor and efficiency of the planting are related to the support, respectively the nutritional pot which consists of stimulants existing in the rooting substrate. The fertilization must start from planting in the pot, until planting in the vineyard (Corbean, 2011). Potted vines could be a good solution to establish a vineyard one season quicker than dormant vines, in warmer areas (Santos et al., 2020). Potted vines need more attention than a dormant vine when planting in the field, and during their management for the first season. Watering is essential for potted vines as they are planted during summer when new, tender plants need the most nutrition (Corbean, 2011).In the experience, the foliar and root fertilization were used equal doses and concentrations for the three variants, the influence being only of the soil mixture. The 35-40 day period, after the second layer of paraffin has been applied and potted, is considered sufficient to obtain potted vines ready to be planted in the vineyard. Fertil Pot type of cardboard ensures good resistance, is not destroyed due to the humidity or during the transport period, it decomposes in the ground after one month after planting (Nechita et al., 2010). The texture of the rooting mixture is influenced by the quality of the peat. The rooting mixture for variant BP (red peat), with a lighter texture, drainage and, permeability of the water of upper irrigation, facilitates heat exchange of medium - pots and creates aeration to prevent infestation of roots with saprophytic fungi (Grohs et al., 2017). At the end of period of rooting, after 40 days, were analyzed the influence of the three variants of the nutritional mix on potted vines yields. The results showed that the best yield of potted vines was obtained in the black peat variant (BP) (91.5%), followed by the red peat variant (RP) (86.2%), and the lowest yield was obtained in the (RS) variant (77.4%), which consisted of only forest land, river sand, and fir sawdust. The results are close to the ones obtained by Călugăr et al., 2020, for the 'Muscat Ottonel' variety for the same variants mixtures (85.4% - subtrate with red peat; 89.1 % -subtrate with black peat and 75.8% - substrate with river sand). The composition in different proportions in the nutritious mixture of peat (red, black), sand, fallow, and sawdust gave different costs to the three variants. The costs of human labor (preparing the rooting mixture, laying the drain bed, filling the pots with the rooting substrate, wetting the pots, planting vines in the pots, irrigating and performing phytosanitary treatments, but also some works on the plant) were equal for the variants with peat (red and black). Due to the greater weight of the pots with sand in variant RS, they were handled more difficult and needed more labor days (Table 3). The yield of quality potted grafts was different due to different cost prices between the three variants. The lowest cost production (0.61 euro/potted vine) was for the rooting substrate with 60% woodland, black peat 25%, sand 10%, sawdust 5% (variant BP). The cost price of variant RP was 0.65 euro/potted vine. The highest cost price was for variant with sand RS (forest land 70%, sand 15%, sawdust 15%), with 0.72 euro/potted vine. The low yield of quality vines (77.4%) recorded by the variant RS caused the higher cost price for this rooting mixture (Table 3).

Generally, the price of the potted vine is higher than grafted vine from field nursery (Borsellino et al., 2010). The selling price of the grafted vine may vary depending on variety, type and economic aspects. Waite et al, 2018 states that at the level of 2017, the selling price for a grafted vine was very different in countries with viticultural tradition. There by, in Hungary the price for one grafted vine was 0.90 euro, in Austria - 1.30-1.50 euro, in France 1.40-1.65 euro, in Germany 1.55 euro, in Italy 1.50-1.60 euro, in South Africa 1.00-1.50 euro, in Spain 1.40-1.65 euro to 2.72-3.00 euro in Australia, 3.00-3.10 euro in New Zealand, 3.16-4.36 euro in Switzerland and 3.20-5.00 euro in the USA.

The selling price was considered equal for each variant, of 1.68 euro/potted vines. After selling the potted vines, variant BP (black peat) could generate a rate of profit of 174.94%. Variants RP and RS could also generate a profit rate of over 100% (158.74% for variant RP and 133.34 % for variant RS). The values of profit ratio were directly influenced by yield of quality of potted vines (root system, grafting point, length and diameter of the main shoot).

During graft planting material production, some losses (2-50%) occur in different stages (grafting, callusing, rooting, and uprooting from the nursery field) (Iliescu et al., 2012).

To increase the quality of grafts material, the hydroponic systems are used in greenhouses to minimize nursery losses (Sengel, 2005).

Table 3. The yield and economic data of potted vines

Variant / EE	RP	BP	RS
	euro/10,000 potted vines		
Vine grafts	2,700.00	2,700.00	2,700.00
FP	1,286.54	1,286.54	1,286.54
FS	22.45	29.83	41.09
BP	-	116.20	-
RP	124.63	-	-
RS	19.47	13.68	25.26
CS	4.47	5.21	17.88
[a]Water	2.43		
[b]Water	29.71		
SB	9.09		
SF	59.30		
Labour 60NDL	1,263.16		1,312.50
FFA	90.00		
OE	5,597.04	5,590.94	5,572.75
QPV (n=10)	86.20±0.26***	91.50±0.13***	77.40±0.41^{ooo}
CP(euro /pcs)	0.65	0.61	0.72
SP	1.68		
IS	14,481.68	15732.00	13003.20
Profit	8,884.56	9,781.06	7,430.45
Profit rate %	158.74	174.94	133.34
MQV %		85.03	
LSD 5%		0.38	
LSD 1%		0.59	
LSD 0.1%		1.00	

EE - Expenses elements; FP- Fertil Pots; FS -fertil soil; CS- conifer sawdust;[a] - water for wetting the pots; [b] - water for irrigation and phytosanitary treatments; SB -Sand for draining bed; SF - Soluble fertilizer; FFA - Fixed fonds amortized; OE - Overall expenses; QPV - Quality of potted vine yield; CP - cost price; SP - Selling price; IS - Income from selling; MQV - Mean quality vine yield; NDL= Normated Day Labour (8 hours/day); Values of quality potted vines % are expressed as mean ± standard deviation ^{*,o}: $p < 0.05$; ^{**,oo}: $p < 0.01$; ^{***,ooo}: $p < 0.001$.

From an economic point of view, the production of vines in pots should be less expensive, due to the shortening of the production cycle, respectively the rooting in the field nursery, phytosanitary treatments, irrigation, mechanical works, additional costs with labor, the surface of the land, different materials additional, and not least, of the last stage, uprooting from field nursery. Some of these stages continue to be carried out, at the definitive planting site, with the specific works and treatments specific to a vineyard.

CONCLUSIONS

The cost of good planting material is amortized during the life of the vineyard. The improved propagation practices that rise grafts quality, compensate any additional cost of production, and will not threaten the viability of planting material businesses. Some propagators may say they receive a low price for grafted vines, so for nurseries are important to adopt practices designed to obtain high yielded grafts and a low production cost. As a general rule, dormant vines are preferable to green-potted vines.

The yield of quality potted grafts was different and generated different cost prices between the three variants. The rooting substrate with 60% woodland, black peat 25%, sand 10%, sawdust 5% (variant BP) had the lowest cost production (0.61 euro/potted vine). The highest cost price was for variant with sand RS (forest land 70%, sand 15%, sawdust 15%), with 0.72 euro/potted vine. The low yield of quality vines (77.4%) recorded by the variant RS caused the higher cost price for this rooting mixture. Profit rates were over 100% for all variants, with the highest for variant with black peat (BP) of 174.94%.

The study focused on a nursery with a specific business model and was conducted to analyze the profitability of the potted vines. This study has territorial limitations, although Jidvei company plays an important role in Romanian grafted grapevine producers. This research may be considered as an exploratory study. It deserves further investigation into different strategic choices within the company system by performing cross-case comparisons. Results obtained in this study may be useful in choosing strategies of small-to-medium grapevine planting materials producers.

The grape plant materials have a high value mainly due to the competitive nature of the grape nursery business, but also of the rapid globalization of the grape and wine community. This results in some fundamental changes in the availability of some grape selections, varieties, and clones that are appropriate for the different climates in the world.

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