

## Conference Paper

# Productivity of Super Intensive Mother Plantations of the Violet Early Variety Under Different Modes of Loading the Bushes with Shoots

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This paper presents the results of a multi-year study aimed at developing super intensive mother plantations. The effect of different modes of shoot load on grape bushes of the hard-to-root variety Violet Early was shown. A comprehensive study of physiological anatomical changes in the vine under various load conditions was conducted to demonstrate the quality and number of cuttings prepared. The efficiency of the creation of super intensive mother plantations on sandy soils in the Chechen Republic was analyzed. The presence of such mother plants allowed timely harvesting of cuttings to use those of the best quality for reproduction. In the experiments, the net income amounted to 23,717.21 thousand rubles, so it almost doubled; and the profitability attained 140.87%, which was 79% more than that in the control.

**Keywords:** grapes, variety, load of shoots, mother plants, cuttings, seedlings, sandy soils, yield.

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## 1. Introduction

Throughout the history of grape cultivation, cuttings of scion varieties have been harvested as a by-product from common fruiting vineyards. Until now, there are no industrial mother plants, where the main product is not bunches and scion cuttings [1, 2]. This system, when bushes are grown for yield and cuttings, does not meet the increased requirements of modern nursery and viticulture. The main disadvantage of the old extensive system is that it does not allow quick reproduction of newly developed more productive varieties [3, 4].

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The development of a new system for cultivation of mother plants for each region of viticulture would allow for testing and mass selection in areas 10–12-fold smaller compared to those currently used. This will help to reproduce pure-grade planting material and to minimize the spread of chronic diseases – bacterial cancer, viral and microplasma diseases [5-8].

As established by L. M. Maltabar, N. D. Magomedov and D. M. Kozachenko [5], the row spacing of 3 meters is optimal for the highest productivity of plantations, good growth and ripening of shoots, accumulation of a sufficient amount of nutrients, mechanized management with due regard to biological characteristics of the varieties for mother plants of scion and rootstock varieties. The inter bush spacing depends on the growth strength and soil conditions.

The necessity and relevance of studying the effect of the load of shoots on bushes in each region and its impact on formation of the photosynthetic potential of plantations were reported by A.M. Negrul, L.T. Nikiforova [9], T.I. Kalmykova [10], and S.G. Voloshin [11]. However, no studies have been carried out on productivity of super intensive mother plantations under various modes of loading the bushes with shoots to grow cuttings in the Chechen Republic. Creation of mother plants for growing cuttings and economic justification of their cultivation is of increased relevance.

**The aim and objectives of the study** are to identify the response of mother plants to different modes of load of the bush with shoots when growing scion cuttings, to substantiate the features of growing the cuttings obtained, their quality and quantity based on a comprehensive study of physiological, anatomical changes in the vine under different modes of load on bushes, and to analyze the efficiency of creating super intensive mother plantations on sandy soils in the conditions of the Chechen Republic.

**Place and conditions of the study.** Shelkovskoy region of the Chechen Republic is characterized by short, cold and little snowy winters with strong winds, where the snow cover that rarely reaches 10 cm is often blown away by the wind. Spring and autumn are short and dry, and summers are long, hot and dry. Winters during the study years were characterized by frequent thaws. The amount of precipitations in winter months in 2014 and 2015 approximately corresponded to the average annual rate. In 2016, precipitation attained 179% of the average annual rate for this period. The minimum air temperature in winter 2014–2016 was minus 18 °C in January 2014 and did not cause the death of the buds.

The average monthly air temperatures in spring–summer were insignificantly higher than the average long-term values. The maximum air temperature was recorded in August 2014, which amounted to +38.6 °C.

The maximum temperature of the soil surface on some summer days reached +58 °C (June 2015). Farming culture differed from the generally accepted one by choice of shoots with removal of inflorescences as the shoots grew longer.

## 2. Methods and Materials

Observations and counts were performed using conventional methods described in the studies by L. M. Maltabar [12], G. P. Malykh [13, 14].

When sampling seedlings, the total number and total thickness of heel roots on 30 seedlings were calculated. The yield of seedlings was counted for each experimental version.

Statistical data processing was carried out by analysis of variance according to B. A. Dospekhov [15, 16] using Microsoft Excel.

In the experiment, the load of shoots on the bush was studied in five versions:

- version I, 26 shoots without removing the inflorescences (control);
- version II – 4 shoots;
- version III – 6 shoots;
- version IV–12 shoots;
- version V –18 shoots.

Planting with vegetative seedlings and short sleeve formation. Each test row is separated by two right and left protective rows. The experiments were performed in threefold repetition. The number of studied bushes in each version is 30, non-covered grape culture. The feeding area of the bushes is 3x1.5 meters.

**The objects of the study** were cuttings, seedlings and fruiting plantings of grapes of the Violet Early variety bred through crossing the varieties Muscat Hamburg and Seversky by the breeders of the Ya. I. Potapenko VNIIViV.

## 3. Results

Light sandy soils, well permeable with high fertility, are most favorable for grape plants; however, the sandy soils in the experimental plot were poor in nutrients. Nitrogen in this type of soil is found by the gross analysis only in a very small amount of 0.03–0.40%.

The humus content varies from 0.60 to 0.65%, the pH ranges from 8.7 to 8.9%, and the general cabinet is 2.2–2.3%. The amount of potassium along the horizons varies from 124 to 147 mg/kg, and that of phosphorus varies from 9.9 to 15.5 mg/kg. The gross content of manganese ranges from 25 to 26.2 mg/kg. The soils are very poor in soluble boron in the range of 0.01–0.14 mg/kg along the soil profile of 0–40 cm, however, boron in deeper layers is not found, and its content is considered low in the amount of 0.65 mg/kg of soil.

The study showed that the moisture content of cuttings relative to the load of cuttings with shoots ranged within significant limits (Table 1). The physiological moisture content of cuttings has a great impact on preservation of the buds, callus and shoot formation, and growth and development of seedlings.

The degree of tissue moisture content greatly affects safety of buds and formation of roots and shoots. An increase in the load of the bushes with shoots provokes a decrease in the physiological moisture content of cuttings. The highest moisture content attained 51.4% in the control under a load of 26 shoots, where it was planned to harvest grape by cuttings, and under a load of 12 shoots, where the inflorescences were removed, the moisture content was 2.8% lower, but in this version the carbohydrate content increased by 5.68%.

When the moisture content of the cuttings was 28–30%, 90–95% of the dormant buds died, and at 40% moisture content, 45–50% of the cutting died. Physiological moisture and carbohydrate content in cuttings can serve as indicators of the ripening of shoots which affects survival of cuttings.

In version IV, a carbohydrate content in the cuttings attained 23.28%, the highest energy reserve for regeneration processes and root system formation.

TABLE 1: Effect of load modes on quality indicators of cuttings (Violet early), %

Version	Content in cuttings		Carbohydrate content in cuttings			Total amount of carbohydrates
	moisture	NPK	monosaccharide	disaccharide	starch	
Control	51.4	7.8	6.43	6.17	5.0	17.6
II	50.1	8.1	7.22	6.23	9.0	22.45
III	48.5	8.3	7.27	6.37	9.3	22.99
IV	48.6	8.7	7.33	6.45	9.5	23.28
V	51.5	8.4	7.26	6.20	9.3	22.76
HCP <sub>05</sub>		0.8				0.55

When rooting cuttings, the released energy is used to form new cells, callus and roots. These processes can occur only in cells containing a certain amount of water, and NPK and carbohydrates, which determine the survival rate, growth and development

of seedlings, play an important role. If the amount of carbohydrates in the vine is less than 5%, the cuttings are not capable of regeneration and die. An increased load of bushes with shoots was followed by an increased leaf area on seedlings up to a certain limit – 12 shoots per bush. The seedlings grown from cuttings of version I exhibited the smallest leaf area, and many of these were found on the lateral shoots.

In the control, the inflorescences were not removed, which results in, the average yield of berries of 40 centners per hectare and 8 thousand cuttings, these were mostly thinner than 5 mm in diameter (non-standard). The rooting rate of cuttings was more intensive in version IV and attained 87.4% with a circular callus, and in version I, it was less by 27%.

In all cases, due to the low content of carbohydrates, potassium, phosphorus and especially nitrogen, shoot development inhibited formation of callus and root system. The yield of cuttings per plant and per ha varied within a wide range. An increase and decrease in the load change the yield and quality of cuttings. Thus, in the control, the yield of marketable cuttings was the lowest and amounted to 8 thousand pieces per hectare or 40 thousand cuttings less than in version IV, 23.4 thousand pieces less than in version II, and 13.4 thousand pieces less than in version III (Table 2).

The structure of shoots also varied, and the share of the wood increased in relation to the pith. The highest quality cuttings were observed in version IV, where the share of phloem + xylem in the cutting diameter amounted to 74.3% or more, which was 3.95% more compared to the control.

TABLE 2: The number and quality of cuttings with respect to the shoot load per plant (Violet early, 2014–2016)

Version	Yield		Tissue size related to diameter,%		Average length of internodes, cm
	Cuttings per plant, pcs	Marketable cuttings, thousand pcs/ha	phloem + xylem	pith	
Control	2.4	8	70.4	29.6	8.41
II	10.1	33.3	72.2	27.8	10.52
III	15	49.9	72.8	27.2	11.8
IV	18	70.9	74.3	25.7	12.39
V	22	53.3	71.2	28.8	12.0
HCP <sub>05</sub>	0.81	1.1	0.2	0.3	

These tissues transport organic substances to various organs and perform storage and mechanical functions, constituent parts of the vascular bundle have a significant effect on regeneration processes. It is believed that the larger the pith, the worse the

quality of the cutting [17]. The internode-to-internode distance in version IV indicates the most intensive growth of shoots by 2.98 cm.

TABLE 3: Effect of the shoot load per plant on the quality and yield of vegetative seedlings (Violet early, 2014–2016)

Version	Yield, %		Quality indicators			plantation survival rate,%	shoot maturation in autumn,%
	cuttings with circular callus during rooting	seedlings	number of roots per seedling pcs	leaf area per seedling, cm <sup>2</sup>	average length of one year shoot, cm		
Control	62.4	40.1	10.0	25.7	107.8	94.8	70.1
II	67.7	46.1	10.3	26.6	112.5	95.1	70.1
III	68.1	49.7	11.6	27.4	113.7	98.2	74.7
IV	77.4	53.9	13.2	27.9	118.4	98.4	75.3
V	72.5	49.0	12.4	27.4	116.0	97.7	73.9
HCP <sub>05</sub>	2.2	0.63	0.5	1.8		0.49	

The initial content of NPK and carbohydrates in cuttings provided a better survival rate of seedlings on the plantation and preservation of dormant buds in winter, which was 9.7% higher compared to the control.

Despite the fact that the Violet Early variety is hard-to-root, the yield of vegetative seedlings was relatively high: 40.1% in the control, and 13.8% higher in version IV. The number of roots per seedling was 3.2 pieces more, the average shoot length gain was 10.6 cm, and the leaf area was 2.2 cm<sup>2</sup>. Functioning of the leaf apparatus of a vegetative seedling, which transforms solar energy into organic matter, has a decisive effect on the survival rate of seedlings on the plantation. A number of researchers noted the correlation of photosynthetic potential with the shoot and yield load of fruit-bearing plants [10, 11, 18].

In the control, seedlings with a smaller leaf surface showed a lower survival rate on the plantation compared with version IV, and slower growth by the end of the vegetation period. The best indicators of maturation of one-year shoots were noted in version IV compared with others.

Calculated economic efficiency of culturing a super intensive type of mother plant under various load modes is presented in Tables 4 and 5.

TABLE 4: Economic efficiency of culturing a super intensive type of mother plant under its various load modes (Violet early)

Indicators	Versions					Deviation of the best version from control
	Control	II	III	IV	V	
Productivity, thous.pcs	8	33.3	49.9	70.9	53.3	62.9
Yield increase in relation to control, thous.pcs	0	25.3	41.9	62.9	45.3	62.9
Production costs per ha, thous.rub	70	96.9	132.5	156.2	166.6	86.2
Additional expenditures for fertilization with regard to their cost, thous.rub	5	18	44.08	69.36	62.51	64.36
Total expenditures, thous.rub	75	114.9	176.58	225.56	229.11	150.56
Cost of the finished products, thous.rub	110	166.5	249.5	354.5	266.5	244.5
Cost of additional products, thous.rub	0	126.5	209.5	314.5	226.5	314.5
Sales proceeds (excluding VAT), thous.rub	110	293	459	669	493	559
Profit per ha, rub	35	178.1	282.42	443.44	263.89	408.44
Net profit per ha, thous.rub	0	148.42	235.35	369.53	219.91	369.53
Cost recovery, thous.rub	0	0.77	0.75	0.61	1.04	0.61
Production cost, rub	9.38	1.96	1.92	1.69	2.32	-7.69
Profitability,%	46.67	129.17	133.28	163.83	95.98	117.16

## 4. Conclusion

To enhance the system of cultivation of cuttings, improve their quality and quantity, increase the yield of seedlings and their survival rate on plantations, the load of bushes with shoots should be optimal, which depends on biological characteristics of the variety and the state of plantings in specific conditions. An excessive shoot load deteriorates their growth, ripening, and quality, which results in a low yield of vegetative seedlings.

The culture of super intensive mother plants on sandy soils in the Chechen Republic allows a 8–10-fold decrease in the area of mother plants of scion varieties and rapid reproduction of the required varieties and clones of classic promising varieties. The presence of such mother plants allows timely harvesting of cuttings for reproduction of

TABLE 5: Economic efficiency of the new technology to culture seedlings from cuttings using a super intensive mother plant (Violet early)

Indicators	Versions					Deviation of the best version from control
	Control	II	III	IV	V	
Yield of seedlings, thous.pcs	641.6	737.6	795.2	862.4	784	220.8
Yield increase in relation to control, thous.pcs	0	96	153.6	220.8	142.4	220.8
Production cost per ha, rub.	15398.4	16964.8	16699.2	16385.6	17404.8	987.2
Additional expenditures, thous.rub	0	78.4	438.7	451.2	108	451.2
Total expenditures, thous.rub	15398.4	17043.2	17137.9	16836.8	17512.8	1438.4
Cost of the finished products, thous.rub	29513.6	33929.6	36579.2	39670.4	36064	10156.8
Cost of additional products, thous.rub	0	4416	7065.6	10156.8	6550.4	10156.8
Sales proceeds (excluding VAT), thous.rub	26830.55	34859.64	39677.09	45297.45	38740.4	18466.9
Profit per ha, rub	11432.15	17816.44	22539.19	28460.65	21227.6	17028.5
Net profit per ha, thous. rub	9526.79	14847.03	18782.66	23717.21	17689.6	14190.4\
Cost recovery, thous.rub	1.62	1.15	0.91	0.71	0.99	-0.91
Production cost, rub	24.00	23.00	21.00	19.00	22.20	-5.00
Profitability,%	61.87	87.11	109.60	140.87	101.01	79.00

those exhibiting best qualities. Calculations on economic efficiency show that the net profit of the best experimental version amounted to 23,717.21 thousand rubles, which is almost 2-fold higher than the control, and profitability was 140.87%, which is 79% more than that of the control.

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