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Medern Methods of Phylloxera-Resistant Rootstock Vine Growth and Formation

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Abstract

The results of testing modern methods of phylloxera-resistant vine growth and formation, which is considered to be one of the important issues in viticulture, is discussed in the article. Vegetation trials were conducted in 2017-2019 in Georgia, Inner Kakheti, on the South-eastern slope of the Caucasus Mountains, where alluvial soils are found. Phylloxera-resistant hybrid rootstock Berlandieri X Riparia Kober 5BB was selected for the field trials. Growth and formation process of the vine took place in the unusual conditions for phylloxera-resistant vine, using cordon systems. Six variants were tested, low trunk, unilateral and bilateral cordons as well as vertical cordon. The most widespread form in the viticultural region - "head trained form without trunk" - was selected as a control variant. The findings have been analyzed and reviewed according to the years. Conclusions have been drawn from the findings and the best variant for the production of high quality, abundant vine shoots has been selected.

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1 Introduction

A new era of worldwide viticulture has started since the appearance of vine pest phylloxera. Vine has been propagated by grafting and new vineyards cultivated by using grafted saplings. Phylloxera-resistant rootstocks are essential for the development of viticulture, not only because of being one of the components of agro technological measures used against phylloxera, but also because of ensuring sustainable grape productivity, chlorosis-resistance, exploitation duration of crops, drought-resistance which are important in response to the challenges of the modern world, such as climate change and global warming. It should be noted that most viticultural regions in the world face high quality rootstock shortage. In order to solve the problem, modern agro technology for Phylloxera-resistant rootstock mother plants should be developed and growth and formation methods of vine rootstocks should be determined. Cordon and espalier forms are used in the mother plants of Phylloxera-resistant vine rootstocks. The most widespread among them are head trained forms without trunk. During this period, the growth and formation of the shoots is intensive as they are formed from easy and sleeping buds. Head trained form in the vine rootstock mother plant implies equal distribution of buds and horizontal growth of the espalier onto 3-4 strand wires. The one which was used as a control variant (Li et al., 2003; Dissmann et al., 2013).

2 Research Aims and Methods

The aim of our research is to develop modern agro-technology for the growth and formation of the vine in the mother plant of phylloxera-resistant vine rootstock. Experiment (field experiment) was conducted in 2017-2019. Hybrid rootstock *Berlandieri X Riparia Kober* 5BB, which is widespread in viticulture, was selected for the experiment. Trial plot is located in the east part of Georgia, Inner Kakheti, Kvareli region, on the Southern slope of the Caucasus Mountains "Tsinkldeebi", where alluvial soils are found. Soil samples were taken from three depths of the trial plot and PH reaction and the amount of K_2O, and P_2O_5 in imbibing nutrients of the plants were determined using laboratory methods.

3 The Results of Agrochemical Analysis

Table 1
Analysis show that soil reaction is close to neutral

Horizon	PH mg/100g in soil	K_2O mg/100g in soil	P_2O_5 mg/100g in soil
0 - 20 cm	6,8	34,0	4,0
20 - 40 cm	6,7	13,0	3,0
40 - 60 cm	6,7	18,0	1,5

The results of the analysis show that soil reaction is close to neutral, the reaction slightly reduces across the soil depth. This is due to soil chemistry as it suffers from Ca^{2+} and Mg^{2+} ion deficiency. There is a diversity of soil nutrients at various soil horizons. The upper, humus horizon is rich in potassium content due to the organic deposits and the influence of micro-organisms (temperature and moisture). K_2O content in 0-20 cm soil depth is 34 mg/100 g. Unequal distribution of potassium is identified across the soil depth. The data show that potassium excretion does not occur though it is washed out in illuvial horizon as increased amount of potassium is found in the lower horizon (20-40cm depth horizon 13,00mg/100g in the soil; 40-60 cm depth – 18mg/100g in the soil). As for the distribution of phosphorus, upper horizons are provided by the amount of absorbing phosphorus. Lack of calcium in the soil causes the increase in the amount of the absorbing phosphorous. The lower layers are not resorbed by phosphorous due to its low solubility. Grape vine crops had been planted two years before the beginning of the research activity (2017 year) and so called "head trained form" were formed. Our aim was to form crops using cordon method (different variants). In spring, when the sprouts reached 30-40 cm length, they were normalized and 1-2 developed sprouts were selected (one sprout for single trunk form and two sprouts for double trunk form). They were grown in a

desirable way in order to form a trunk and cordons (arms). After desirable formation, shoot tips were cut away in order to stimulate active growth and formation of the sprouts (Lawo et al., 2011; Chertemps et al., 2021).

At the development phase of 3-4-leaf sprouts, we conducted agro measurements of removing non-desirable, additional spurs, cleared the trunk completely, and left the developed sprouts on the cordon where we had intended to develop pruning circle. Other spurs were considered as undesirable and therefore removed. The remained sprouts were trained as the crop-offshoot. Secondary sprouts were removed periodically and if needed, tied up on the cordon tiers horizontally in accordance with the variants listed below (Farfán et al., 2022; Meza et al., 2018). The second and third vegetation (2017-2018) year experiment was conducted in the already formed plantation, i.e. when the trunk of the vine and cordons are formed in accordance with the trial variants. During the vegetation year, the following agro technological measures were implemented: the cultivation of the soil, fighting against weeds, green operations, etc. These measures were the same for all variants. The following variants were tested in terms of the offshoot productivity in 2017 – 2019:

1. Variant I - "Vertical Cordon"
   Vine is trained on 4-tier espalier, pruning circle is formed along each tier. Sprouts will be trained horizontally on the cordon appropriate wire;
2. Variant II – "low trunk, long, single cordon"
   The trunk is 40cm high, the arm is formed on the first tier of the four-tier espalier, Its length is 220cm. 7 pruning circles are formed there. Arising sprouts will be distributed equally and trained horizontally on the upper three tiers of the espalier;
3. Variant III - "Low trunk, short single cordon"
   The trunk is 40cm high, the arm is formed on the first tier of the four tier espalier, and its length is 120 cm. 5 pruning circles are formed there. Arising sprouts will be distributed equally and trained horizontally on the upper three tiers of the espalier;
4. Variant IV - "Low trunk, long bilateral cordon with two trunks"
   The trunk is 40 cm high, the arms are formed on the first tier of a four-tier espalier, the length of one arm is 110 cm and 4 pruning circles are formed on it, i.e. there are totally 8 pruning circles on one vine. Arising sprouts will be distributed equally and trained horizontally on the upper three tiers of the espalier;
5. Variant V - "low trunk, short bilateral cordon with two trunks"
   The trunk is 40cm high, the arms are formed on the first tier of a four-tier espalier, and the length of one arm is 60cm. There are 3 pruning circles on it, i.e. there are totally 6 pruning circles on one vine. Arising sprouts will be distributed equally and trained horizontally on the upper three tiers of the espalier;
6. Variant VI - "low trunk, long bilateral cordon with one trunk"
   The trunk is 40cm high, the arms are formed on the first tier of a four tier espalier, the length of one arm is 110 cm on which 4 pruning circles are formed, i.e. there are totally 8 pruning circles on one vine, the sprouts of which will be distributed equally and trained horizontally on the upper three tiers of the espalier;
7. The control variant - "head trained form without trunk"
   Accepted rule of phylloxera-resistant vine training and formation - equal distribution and horizontal training of the sprouts on each wire of a three tier vertical espalier.

After completing vegetation, we calculated the productivity of the rootstock material in accordance with relevant variants and parameters (Martínez-Ballesta et al., 2010; Nisini et al., 2002).

Calculation elements

In the first year of the formation (2017), the following was calculated in the mother plant:

1. The whole length of the vine shoot in centimeters;
2. The mature part of the vine shoot in centimeters;
3. The length of a standard thick (6-12mm) offshoot which is suitable for grafting (in centimeters).

In 2018 - 2019 the whole length of the vines sprout was being measured with its mature and immature parts. The thickness – diameter of the mature shoot was also measured, and they were grouped according to diameters: < 6 mm; 6-7 mm; 8-10 mm; 11-12 mm; > 12 mm. Each division included 5 plant roots.

Table 2
The calculation results of the experiment conducted during vegetation years 2017-2019

Variant	Amount of vine shoots (number, 40 cm) In one-hectare plot		
	2017	2018	2019
Control "head trained form"	40 000	148 800	268 800
vertical cordon	69 280	127 200	177 800
low-stemmed, long, unilateral cordon	94 280	189 600	249 120
low-stemmed, short, unilateral cordon	76 880	151 200	201 040
Low-stemmed, long, bilateral cordon with two trunks	106 000	285 600	391 200
Low-stemmed, short, bilateral cordon with two trunks	88 160	208 800	271 200
Low-stemmed, long, bilateral cordon with a single trunk	75 840	199 200	285 480

According to the calculations of the first vegetation year (2017) of cordon trained vine formation, 40 000 pieces of 40cm long grafting offshoot (6-12 mm thick) were obtained in one-hectare plot from the control variant - the vine crop formed by "head trained form without trunk" - which is recognized in production.

1. 69 280 pieces of the offshoot were obtained from vertical cordon trained vine crops. The result is 73% higher than the result got from the control variant - vine formed by "head trained form without trunk".
2. 75 840 pieces of offshoots were obtained from the variant – long bilateral single trunk cordon. It is 90% higher than the control variant.
3. 76 880 pieces of offshoots were obtained from the variant – short single cordon - which is 92% higher than the control variant.
4. 88 160 pieces of offshoots were obtained from the variant – short bilateral cordon with two trunks - which is 120% higher than the control variant.
5. 94 280 pieces of offshoots were obtained from the variant – long single cordon - which is 136% higher than the control variant.

Among the tested variants the best result was got from the variant – long bilateral cordon with two trunks. 106 000 pieces of standard offshoots were obtained from the variant which is 165% higher compared to the control variant.

Table 3
The productivity of the variants tested in 2018 (thickness in diameters)

		>12 mm	10-12mm	8-10 mm	6-8 mm	6> mm	immature
Head trained form without trunk (control variant)	length (cm)	0	0	2524	1197	707	176
	Unit (120 cm long)	0	0	21	10	6	1.5
Vertical cordon	length (cm)	0	0	1671	1513	1525	233
	Unit (120 cm long)	0	0	14	12.5	12.5	2
Long, unilateral cordon	Length (cm)	0	0	2508	2252	1047	489
	Unit (120 cm long)	0	0	21	18,5	8.5	4

Short, unilateral cordon	length (cm)	0	0	1691	2124	1061	266
	Unit (120 cm long)	0	0	14	17.5	8.5	2
Long, bilateral cordon with two trunks	Length (cm)	0	0	3308	3836	2300	496
	Unit (120 cm long)	0	0	27.5	32	19	4
Short, bilateral cordon with two trunks	length (cm)	0	0	2671	2574	1658	315
	Unit (120 cm long)	0	0	22	21.5	13.5	2.5
Long, bilateral cordon with a single trunk	length (cm)	0	0	1423	3563	1501	355
	Unit (120 cm long)	0	0	12	29.5	12.5	3

According to the calculations performed in 2018 after completing vegetation, 148 800 pieces of 40 cm long (6-12mm thick) offshoots suitable for grafting were obtained , in one-hectare plot from the control variant – "head trained form without truck".

1. 127 000 pieces of same parameter offshoots suitable for grafting were obtained in the same area from the variant – "vertical cordon". It is 15% less than the control variant.
2. 151 200 pieces of offshoots suitable for grafting were obtained from the variant – "short single cordon"- which is 2% higher than the control variant.
3. 189 600 pieces of offshoots suitable for grafting were obtained from the variant – "long single cordon" - which is 27% higher than the control variant.
4. 199 200 pieces of offshoots suitable for grafting were obtained from the variant – "long bilateral cordon with a single trunk' - which is 34% higher than the control variant.
5. 208 800 pieces of offshoots suitable for grafting were obtained from the variant – "short bilateral cordon with two trunks" - which is 40% higher than the control variant.

Among the tested variants the best result was got from the variant - "long bilateral cordon with two trunks" - with 285 600 pieces of offshoots suitable for grafting, which is 92% higher compared to the results of the control variant.

Table 4
The productivity of the variants tested in 2018 in one-hectare plot (thickness in diameters)

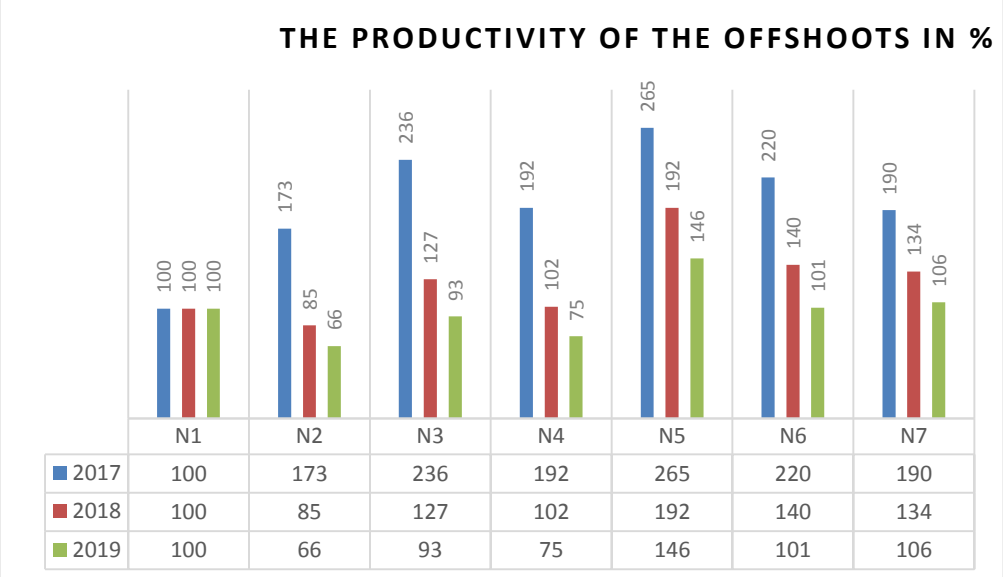
		>12 ∂∂	10-12 ∂∂	8-10 ∂∂	6-8 ∂∂	6> ∂∂	immature
Head trained form without trunk (control variant)	length (cm)	0	2660	1995	2065	1120	245
	Unit (120 cm long)	0	22	16.5	17	9	2
Vertical cordon	length (cm)	0	0	1831	2614	1409	766
	Unit (120 cm long)	0	0	15	21.5	11.5	6
Long, unilateral cordon	length (cm)	0	0	3498	2730	2120	625
	Unit (120 cm long)	0	0	29	22.5	17.5	5
Short, unilateral cordon	length (cm)	0	0	3409	1617	1764	539
	Unit (120 cm long)	0	0	28	13	14.5	4

Long, bilateral cordon with two trunks	length (cm)	0	0	5100	4680	1534	702
	Unit (120 cm long)	0	0	42.5	39	12.8	5.5
Short, bilateral cordon with two trunks	length (cm)	0	0	3700	3080	1890	760
	Unit (120 cm long)	0	0	30.5	25.5	15.5	6
Long, bilateral cordon with a single trunk	length (cm)	0	0	3367	3770	1430	728
	Unit (120 cm long)	0	0	28	31	11.5	6

According to the calculations performed after completing vegetation in 2019, 268 800 pieces of 40 cm long (6-12mm thick) offshoots suitable for grafting were obtained , in one-hectare plot from the control variant – "head trained form without trunk".

1. 177 800 pieces of the same parameter offshoots suitable for grafting were obtained from the variant - vertical cordon - which is 34% less than the control variant.
2. 201 040 pieces of offshoots suitable for grafting were obtained from the variant – "short single cordon" - which is 25% less than the control variant.
3. 249 120 pieces of offshoots suitable for grafting were obtained from the variant - – "long single cordon" - which is 7% less than the control variant.
4. 271 200 offshoots suitable for grafting were obtained from the variant – "short bilateral cordon with two trunks" - which exceeds 1% of the control variant.
5. 285 480 pieces of offshoots suitable for grafting were obtained from the variant — "long bilateral cordon with a single trunk" - which exceeds 6% of the control variant.

Among the tested variants the best result was got from the variant – "long bilateral cordon with two trunks" - from which 391 200 pieces of offshoots suitable for grafting were obtained. The result exceeds 46% of the control variant.



4 Conclusion

Based on the results of the cordon forms tested in phylloxera-resistant rootstock mother plant in 2017 – 2019, it is clear that the productivity of the offshoots (6-12 mm) suitable for grafting which was obtained from the vinecrop formed with "long bilateral cordon with two trunks" is 101% higher than the results of the control variant and proves

to be the best among the tested variants (Dexter, 1988; Franzluebbers, 2002). According to the results based on the data of offshoot productivity, among the best variants the distinguished one "low trunk, long bilateral cordon with two trunks" exceeds 165% of the control variant (head trained form without trunk) in 2017, 92% in 2018 and 46% in 2019. According to the findings, for the growth and formation of phylloxera-resistant rootstock vine in a mother plant, recommendation should be given to "low trunk, long bilaterial cordon with two trunks" (Reeves et al., 1997; Godwin, 2007).

Conflict of interest statement
The authors declared that they have no competing interest.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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