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SHORT COMMUNICATION

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The influence of the type of root on the rooting of green roots of *Viburnum opulus*

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Abstract

The conducted research is devoted to issues related to the propagation of rooted cuttings of common *Viburnum opulus*. As the research results indicate, significant death among rooted cuttings occurs during the propagation period. The purpose of the study was to investigate the effect of different types of cuttings on the rooting of the cuttings of *Viburnum opulus* during this researched period. It should be noted that the rooting success of the cuttings was high. The cuttings were collected from native *Viburnum opulus* mother plants under the conditions of the nebulizing installation of the winter garden of the «Podillia» Botanical Garden of the Vinnytsia National Agrarian University within the framework of the implementation of initiative topics at the Department of Forestry and Horticulture. According to the results of our research, the highest percentage of death among rooted *Viburnum* cuttings, across all studied varieties, was observed in the variant where the cuttings were grown at the rooting site. In this variant, significant death rates ranging from 18.7% to 35.4%, depending on the variety, occurred during the growing season. The reason for this is very small areas of nutrition and, accordingly, the thickening of plants. In contrast, when rooted cuttings are transplanted in autumn, death rates during overwintering range from 10.4% to 18.7%, with lower rates during transplanting and the growing season. During spring transplanting, the death of root plants is observed mainly during overwintering and transplanting, to a lesser extent during the growing season. Comparing the growth indicators of rooted cuttings planted in open ground and those grown in containers, it should be noted that there is a significant advantage in the development of the root system and the above-ground part in container-grown cuttings.

Key words

Viburnum opulus, reproduction, grafting, green cuttings, botanical garden

Introduction

The scientific achievements of specialists in the fields of forestry and horticulture, aimed at creating green spaces, are characterized by significant ecological, social and economic perspectives (Bakhmat et al. 2023; Didur et al. 2019; Pantsyreva et al. 2020; Petrichenko et al. 2017). However, in the conditions of urban landscapes, which are unnatural and stressful environments for plants, green spaces often encounter some difficulties in functioning and adapting to the urban ecosystem (Bulgakov et al. 2023; Petrychenko et al. 2018). Common *Viburnum* belongs to them – valued for its food, medicinal, soil-protecting and decorative prop-

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erties. The genus *Viburnum* (*Viburnum* L.) comprises about 220 species of plants distributed across Eurasia, North America and North Africa. These are mostly evergreen and deciduous shrubs or small trees. The life expectancy of *Viburnum* is 50–60 years. All types of *Viburnum* are highly decorative and have a large number of cultivars. They can be used in all types of plantations. In addition to its decorative properties, *Viburnum* has other useful properties: it is a good honey plant and a medicinal and food plant (Maier 2019; Matusiak 2020). Furthermore, a new direction – medicinal horticulture – has developed worldwide (Puyu et al. 2021; Snitynskyi et al. 2023). Its tasks include breeding crops whose fruits can prevent or cure various diseases (Mazur et al. 2020; Pantsyreva et al. 2024). About 40% of the total number of medicinal products are herbal preparations. Raw materials for the production of almost half of them are wild plants, including *Viburnum opulus* (Desurmont et al. 2020).

Viburnum plants are among the oldest decorative and medicinal forest plants, used in gardening, medicine and decorative gardening. They are valued for their ecological plasticity and decorative qualities (the shape and architecture of the crown, the morphology of the leaves, etc.), which make them suitable for creating green landscapes in conditions of urbophytocenoses.

The cultivation of planting material involves using the seed method for *Viburnum* propagation to create understories and stabilize ravines and beams. Due to its high heterozygosity, seed propagation during the cultivation of seedlings does not preserve shape characteristics. Therefore, for Viburnum, valued as a fruit-bearing, medicinal, food and decorative species, it is important to use such breeding methods that ensure the production of genetically homogeneous seedlings that retain their form and do not differ from the mother individuals in terms of their economic and valuable characteristics. This condition is met by vegetative methods of reproduction, particularly vegetative reproduction (Konstantinov et al. 2018; Neyko et al. 2019).

Different types of *Viburnum* are used in landscaping of territories – as solitaires, in group plantings and as hedges. These plants are planted in various places of general, limited and special purpose: arboretums, botanical gardens, parks, squares, boulevards, territories of educational institutions, homesteads and private territories (Bulgakov et al. 2023; Didur et al. 2020).

In recent years, methods of green and woody cuttings for fruit and berry plants have been quite successfully used in many nurseries. This method makes it possible to intensify the process of growing *Viburnum* planting material. From both production and biological aspects, this method is highly promising as it enables mass cultivation of genetically homogeneous *Viburnum* planting material. Additionally, it has opened up greater opportunities for the mechanization of numerous production processes. The development of production equipment for the artificial creation of fog, the use of polyethylene films and synthetic growth regulators have made grafting one of the leading reproduction methods for the researched species in the decorative horticulture of Ukraine (Ivanyshyn et al. 2021; Maier 2019; Monarkh and Matusiak 2020).

Growing seedlings from green cuttings is a long-known method of vegetative propagation, but it has not yet gained sufficient popularity due to the markedly different abilities of cuttings to form roots, which vary not only between breeds but also between varieties. Therefore, in horticulture practice, seedlings are mostly grown this way selectively, taking into account their known properties in advance of rooting (Desurmont and Weston 2014; Pantsyreva 2019).

In recent years, the cultivation of tree and shrub plants has become increasingly important due to their relative ease of reproduction, capriciousness and abundance various species and varieties, which vary in crown shape and leaf color. One of the advantages of *Viburnum* is its wide range of uses (Desurmont et al. 2019; Vasylevskyi et al. 2021).

The process of obtaining standard planting material for fruit and berry crops using green cuttings technology involves several stages: rooting green cuttings under conditions of artificial fog, storing cuttings during the winter period and growing rooted cuttings. Currently, the technology for rooting green cuttings has been extensively developed, with optimal microclimatic conditions and methods for directed, deterministic influence on the process of adventitious rhizogenesis clearly defined. However, the aspect of growing rooted cuttings remains insufficiently studied and is one of the limiting factors in obtaining root-own planting material and in the wider introduction of green cuttings technology within fruit nursery practices (Pantsyreva et al. 2023).

After analyzing the works of scientists, it becomes evident that the processes of adventitious rhizogenesis in

green cuttings are dependent on the type of cutting (Honcharuk et al. 2022; Mazur et al. 2019, 2020; Pantsyreva et al. 2020). In the practice of using green cuttings, it is customary to reduce the area of the leaf and the number of nodes on the cuttings to decrease the area of evaporation however, this practice can impair the supply of photosynthesis products to the cuttings. Therefore, a differentiated approach is necessary to determine the optimal type of cuttings, ensuring the provision of physiologically active and plastic substances for the regeneration of lost organs in green cuttings (Dubik et al. 2024; Hetman et al. 2024; Hnatiuk et al. 2019; Mazur et al. 2021; Neyko et al. 2021; Petrychenko et al. 2024; Titarenko 2022).

The rooting process of cuttings depends on many factors, including the season and location of collecting the source material, method of preparation and processing of the cuttings, composition of the substrate, microclimate in which root formation occurs, care of the planted cuttings and biological characteristics of the species being propagated by cuttings (Lutkovska 2020; Matusyak et al. 2021).

The purpose of the study was to investigate the effect of different types of cuttings on the rooting of *Viburnum opulus* during the researched period, noting that there was a high rooting rate among the cuttings.

To achieve this goal, the following tasks must be completed:

– Conduct an analysis of literary sources and summarize information on distribution and morpho-biological features.
– Develop scientific foundations for the introduction to culture, studying its reproductive characteristics, assessing its productive potential and proposing practical applications.

Material and methods

Scientific and experimental research was conducted during 2020–2022 at the architectural and exposition site of the Department of Forestry and Horticulture, Faculty of Ecology, Forestry and Horticulture of the Vinnytsia

Figure 1. A nursery of green cuttings in conditions botanical garden «Podillia» of the Vinnytsia National Agrarian University

National Agrarian University. Cuttings were collected from native *Viburnum* mother plants under the conditions of the nebulizing installation of the winter garden of the «Podillia» Botanical Garden at Vinnytsia National Agrarian University. Shoots were selected during phases of flowering, intensive growth and slowing down of growth (Lutkovska 2020; Monarkh and Pantsyreva 2019; Tkach et al. 2024; Tkachuk et al. 2024). The lower section was made in the middle of the internode, and the upper one – directly above the node (Balabak 2003; Mazur et al. 2021; Neyko et al. 2023). Each experiment was repeated four times, with 48 cuttings in each repetition.

The study on the influence of cutting type (number of nodes) on the rooting and growth of green *Viburnum* cuttings of the Velikoplidna variety, depending on the metamerism of the shoot, was conducted according to the following scheme (Fig. 1):

Results

The rooting process of cuttings depends on many factors, including the season and location of collecting the source material, method of procurement and processing of cuttings, composition of the substrate, microclimate in which root formation occurs, care of the planted cuttings and biological characteristics of the species being propagated by cuttings. Analyzing the effect of different types of cuttings during the period of mass flowering on rooting, it should be noted that rooting increases with an increase in the number of nodes on the planted cuttings (Tab. 1).

The rooting rates of single-node cuttings harvested from different parts of the shoot averaged over three years were as follows: apical – 32.4%, medial – 41.7% and basal – 54.1%. Among single-node cuttings, those harvested from the basal part exhibited better rooting – 1.7 times higher than apical cuttings and 1.3 times more than medial cuttings. The rooting of two-node cuttings from the apical part during the period of research was 49.7%, which is 9.2% less than the rooting of similar cuttings from the medial part of the shoot and 22% less than two-node basal cuttings. Three-node cuttings had a significant advantage in rooting, regardless of the part of the shoot from which they were harvested. It should be noted that the rooting rate of three-noded cuttings from the apical part of the shoot averaged 65.1% during the research period, which is 15.4% more than two-noded ones and 32.7% more than similar one-noded ones. Rooting of three-node cuttings prepared from the medial parts is also significantly higher than that of two-node and one-node medial cuttings, by 13.4% and 30.6%, respectively. The rooting percentage of three-node basal cuttings was 82.9%, two-node 71.7% and one-node only 54.1%.

Table 1. Study of the rooting of green *Viburnum* cuttings of the ordinary Velikoplidna variety depending on the type of cutting, %

Type of cutting (number of nodes)	2020	2021	2022	Average for 3 years
Apical part				
1	34.2	33.1	30.1	32.4
2	50.1	49.6	49.7	49.7
3 (control)	64.2	65.8	65.3	65.1
Medial part				
1	40.2	43.4	41.6	41.7
2	58.3	61.1	57.5	58.9
3 (control)	70.3	74.1	72.6	72.3
Basal part				
1	54.1	55.2	53.2	54.1
2	72.1	72.5	70.5	71.7
3 (control)	80.2	84.7	83.8	82.9
LSD_{05}	4.4	6.2	5,6	

Common *Viburnum* cuttings that root better later form a more developed root system compared to cuttings where root formation occurred later (Tab. 2).

In the calculation per cutting, the total number of roots of the first- and second-order branching in one-node cuttings from the apical part of the shoot was 168.9 pieces, while in two-node apical cuttings this figure significantly increased to 223.8 pieces. The largest number of roots of the first- and second-order branching (255.2) was recorded in three-node cuttings. Analyzing the growth of the adventitious root system in different types of medial cuttings, it should be noted that three-node cuttings had a significant advantage in terms of this indicator. The total number of roots in this variant was 291.3 pieces, which is 61.2 pieces more than in two-knotted cuttings and 119.5 pieces more than in single-knotted cuttings. The total number of roots of

Table 2. Study of the influence of the type of cutting on the number of roots in the cuttings of the Velyoplidna variety, pcs.

Type of cutting (number of nodes)	2020		2021		2022		Average for 3 years	
	root branching order							
	1	2	1	2	1	2	1	2
Apical part								
1	13.6	100.2	15.0	101.4	15.5	142.4	14.7	114.6
2	19.2	154.6	19.5	175.4	22.1	182.6	20.2	170.8
3 (control)	26.7	230.2	23.2	209.7	28.0	248.0	25.9	229.3
Medial part								
1	14.4	131.2	17.2	140.7	21,2	190.7	17.6	154.2
2	19.5	200.4	23.3	200.2	26,8	210.2	26.5	203.6
3 (control)	24.7	244.5	29.7	260.8	34,7	276.7	29.7	261.6
Basal part								
1	20.1	200.2	23.4	214.3	27.1	219.6	23.5	211.3
2	30.9	273.4	29.6	241.7	32.2	271.5	30.9	262.2
3 (control)	38.9	310.2	35.3	318.7	38.7	331.0	37.5	319.9
LSD_{05}	3.1	7.1	2.3	10.1	4.4	13.2		

three-node cuttings harvested from the basal part of the shoot is 357.4 pieces per cutting, while for two-node and one-node basal cuttings, it was 293.1 pieces and 234.8 pieces, respectively.

Table 4. Growth biometry of rooted cuttings of the Velikoplidna variety, harvested during the period of mass flowering, depending on the type of cutting, cm

Type of cutting (number of nodes)	2020	2021	2022	Average for 3 years
Apical part				
1	0.0	1.0	0.1	0.3
2	2.8	4.0	3.1	3.3
3 (control)	5.1	6.7	7.9	5.8
Medial part				
1	2.9	3.5	5.0	3.8
2	4.9	6.7	7.8	6.4
3 (control)	8.0	9.2	10.5	9.2
Basal part				
1	5.9	7.7	7.7	7.1
2	8.2	10.1	10.1	9.4
3 (control)	12.1	13.7	14.9	13.5
LSD_{05}	0.8	0.5	0.4	

Depending on the type of scion, there was a difference in the length of the adventitious roots (Tab. 3).

The total length of the roots of the first- and second-order branching in single-node cuttings from the apical part was 287.7 cm, from the medial part – 341.4 cm, from the basal part – 477.5 cm. In two-node cuttings, this indicator was, 451.4 cm, 469.3 cm, 641.2 cm, respectively.

Three-node cuttings exhibited the most extensive root system. Cuttings of this type harvested from the apical part of the shoot had a total root length of 632.7 cm, while those from the basal part measured 790.2 cm.

It should be noted that the growth of the aerial part of the three-node cuttings significantly exceeded the one-node ones (Tab. 4). Over the three years of research, three-noded cuttings harvested from the apical part of the shoot exhibited an average growth of 5.8 cm, whereas two- and one-node cuttings showed growth of 3.3 and 0.3 cm, respectively. A significant advantage in length growth of three-node cuttings was also observed in those harvested from the medial and basal part of the shoot.

Analyzing the rooting of cuttings harvested during the period of intensive growth and fading of shoot growth, it should be noted that the rooting of cuttings, as well as in the period of mass flowering, significantly increased with an increase in the number of nodes on the planted cuttings.

The rooting rate of single-node cuttings harvested during the period of intensive shoot growth from different parts of the shoot was 47.6–60.1% (Fig. 2).

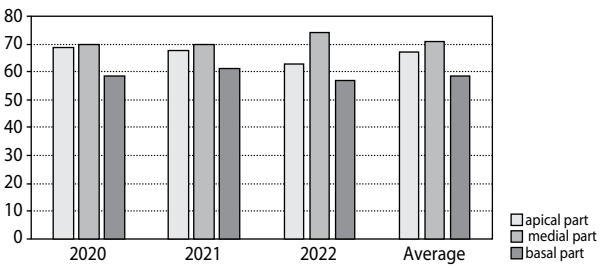

Figure 2. The influence of the type of cutting on rooting in green *Viburnum* cuttings of the ordinary variety Velikoplidna, harvested from intensive growth of shoots, %

Table 5. Rooting of cuttings of the Velikoplidna variety harvested during the period of slow growth of shoots, depending on the type of cutting, %

Type of cutting (number of nodes)	2020	2021	2022	Average for 3 years
Apical part				
1	30.5	30.7	29.5	30.2
2	43.1	40.2	43.2	42.1
3 (control)	53.5	51.1	55.9	53.5
Medial part				
1	21.2	20.2	20.4	20.6
2	37.1	34.1	37.5	36.2
3 (control)	49.5	47.1	50.1	48.9
Basal part				
1	20.4	19.6	20.9	20.3
2	32.2	29.3	31.1	30.8
3 (control)	44.9	45.2	47.8	45.9
LSD_{05}	6.3	6.1	5.7	

Among this type of cuttings, a significant advantage in rooting was observed in cuttings harvested from the medial part of the shoot. A significant advantage in rooting of two-node cuttings was recorded in cuttings harvested from the medial parts of the shoot compared to two-node apical and basal ones. During the period of mass flowering, three-node cuttings had a significantly higher rooting rate, regardless of the part of the shoot from which they were prepared, averaging 72.1–84.2% during the research period.

When analyzing the rooting of different types of cuttings selected during the period of slow growth of shoots, it should be noted that three-node cuttings showed a significant advantage over other cuttings in this period, achieving 45.9–53.5% depending on the shoot zone (Tab. 5).

Three-node cuttings harvested from the apical part showed the best rooting – 53.5%, which is 11.4% more than two-node and 23.3% higher than single-node cuttings also harvested from the apical part of the shoot. Among the different types of cuttings harvested from the medial part, three-node cuttings were also noted for their better rooting – 48.9%, while single-node – 20.6% and two-node – 36.2%. The lowest percentage of rooted cuttings was observed in single-node cuttings harvested from the basal part of the shoot.

Table 6. The influence of the type of cutting on the number of roots in cuttings of the Velikoplidna variety harvested during the period of intensive growth of shoots, cm

Type of cutting (number of nodes)	2020		2021		2022		Average for 3 years	
	root branching order							
	1	2	1	2	1	2	1	2
Apical part								
1	14.7	131.7	19.1	95.7	15.5	102.6	16.4	110.0
2	19.6	175.6	25.1	131.7	21.1	166.4	21.9	157.9
3 (control)	24.2	206.5	31.2	203.5	27.2	215.2	27.5	208.4
Medial part								
1	16.5	120.4	21.1	133.6	16.1	123.6	17.9	125.8
2	22.1	181.7	27.1	200.1	23.1	191.2	24.1	191.0
3 (control)	27.0	222.5	34.6	294.5	30.0	265.0	30.5	260.6
Basal part								
1	10.9	75.7	14.9	92.6	12.2	81.7	12.6	83.3
2	15.1	100.7	20.4	127.6	18.1	110.4	17.5	112.9
3 (control)	18.7	150.5	26.2	180.7	24.2	170.7	23.1	167.3
LSD_{05}	2.3	9.6	3.3	9.5	2.4	11.5		

The total number of roots of the first- and second-order branching in three-noded cuttings harvested during the period of intensive shoot growth, depending on the shoot zone, was 190.4–235.9 pieces, whereas this indicator in two-noded cuttings was 130.4–215.1 pieces and in single-noded ones 95.9–143.7 pieces. Among cuttings harvested from different parts of the shoot, in this period, a significant advantage was recorded in medial cuttings. Three-node medial cuttings had 54.6 more pieces of roots compared to similar apical cuttings and 100.1 more pieces compared to basal ones. In two-noded medial cuttings, the total number of roots of the first- and second-order branching was 215.1 pieces, whereas for apical ones it was 179.8 pieces and for basal ones it was 130.4 pieces (Tab. 6).

The length of roots in cuttings increased significantly with an increase in the number of nodes. The length of the roots of the first order per cutting was 132.1 cm from the apical part of the shoot, 160.8 cm from

the medial part and 109.8 cm from the basal part. An increase in the number of nodes to two caused a significant increase in the length of the roots of the first order: in apical ones – up to 200.6 cm, in medial ones – 229.8 cm, in basal ones – 70.8 cm compared to single-node ones. Throughout the research period, three-node cuttings had a significant advantage in terms of this indicator compared to both two-node and one-node cuttings (Tab. 7).

The number of roots in the cuttings harvested from the apical part of the shoot during the period of slow growth of the shoots, regardless of the type of cutting, significantly outweighs the cuttings harvested from the medial and basal parts of the shoot (Tab. 8).

The decrease in the number of nodes led to a significant decrease in the number of roots in two-node and one-node cuttings. Thus, in two-node apical cuttings, the number of roots of the first- and second-order branching was 111.4 pieces, in medial ones – 66.4 pieces, basal – 57.8 pieces.

In single-node cuttings, the largest number of roots was recorded in the apical ones – 59.7 pieces, the smallest in the basal ones – 37.6 pieces.

Apical cuttings significantly prevailed in the length of adventitious roots (Tab. 9).

The total length of the roots of the first- and second-order branching in two-node cuttings harvested from the apical part of the shoot was 164.6 cm, the least branched among this type of cuttings was the adventitious root system of basal cuttings – 63.8 cm. The root system of two-node cuttings was more developed compared to single-node ones apical cuttings – 275.4 cm, which is 81.1 cm more than medial and 115.3 cm more than basal cuttings. In three-node apical cuttings, the total length of the roots was 425.4 cm, in medial – 316.8 cm, basal – 262.9 cm.

Among the different types of cuttings selected during the period of intensive growth of shoots, the growth of three-noded

Table 7. The influence of the type of cutting on the length of the roots in cuttings of the Velikoplidna variety harvested during the period of intensive growth of shoots, cm

Type of cutting (number of nodes)	2020		2021		2022		Average for 3 years	
	root branching order							
	1	2	1	2	1	2	1	2
Apical part								
1	120.4	192.7	155.6	192.6	120.2	172.4	132.1	185.9
2	192.6	265.6	228.7	277.2	175.7	255.3	200.6	266.1
3 (control)	260.6	321.6	321.9	343.8	264.6	312.1	282.3	325.8
Medial part								
1	155.2	175.5	200.5	215.6	126.9	192.4	160.8	194.5
2	210.5	260.1	277.4	301.7	201.5	281.4	229.8	281.1
3 (control)	280.8	359.9	366.1	386,2	290.7	373.7	302.5	373.2
Basal part								
1	95.6	100.1	111.7	175.2	112.3	121.7	109.8	132.3
2	120.7	170.2	192.6	243.6	201.7	210.2	171.6	208.0
3 (control)	195.8	260.4	273.8	325.2	295.7	295.1	254.9	302.8
LSD_{05}	9.8	8.5	8.3	8.1	7.2	7.5		

Table 8. The influence of the type of cutting on the number of roots in cuttings of the Velikoplidna variety harvested during the period of slow growth of shoots, pcs.

Type of cutting (number of nodes)	2020		2021		2022		Average for 3 years	
	root branching order							
	1	2	1	2	1	2	1	2
Apical part								
1	13.3	47.1	13.1	49.2	11.3	45.5	12.5	47.2
2	17.1	95.5	18.2	91.1	17.2	95.1	42.1	93.9
3 (control)	21.7	139.5	21.2	125.7	23.7	136.7	53.5	133.9
Medial part								
1	8.4	40.2	8.8	30.2	8.2	32.2	8.4	34.2
2	12.1	60.1	13.8	50.1	12.1	51.4	12.6	53.8
3 (control)	16.7	88.5	19.4	79.7	18.2	89.7	18.7	85.9
Basal part								
1	7.1	29.1	7.0	24.8	9.5	38.1	7.0	30.6
2	11.0	50.9	10.1	41.4	10.7	50,1	10.4	47.4
3 (control)	15.2	71.2	16.2	70.7	15.5	72.5	15.6	71.4
LSD_{05}	3.2	6.1	4.1	5.2	3.7	8.1		

Table 9. The influence of the type of cutting on the total length of the roots in cuttings of the Velikoplidna variety harvested during the period of slow growth of shoots, cm

Type of cutting (number of nodes)	2020		2021		2022		Average for 3 years	
	root branching order							
	1	2	1	2	1	2	1	2
Apical part								
1	63.5	121.4	72.1	100.9	55.4	80.7	63.6	101.0
2	120.4	172.2	110.7	172.4	110.3	140.2	113.8	161.6
3 (control)	190.3	248.5	189.5	232.3	176.9	239.1	185.5	239.9
Medial part								
1	42.2	61.1	41.1	51.9	39.9	50.2	41.1	54.4
2	81.2	110.3	92.7	100.4	87.7	110.7	87.2	107.1
3 (control)	106.7	171.2	148.8	198.1	135.8	189.9	130.4	186.4
Basal part								
1	29.2	49.4	30.4	59.9	40.2	55.4	33.2	54.9
2	52.4	82.6	71.2	110.7	71.3	92.3	64.9	95.2
3 (control)	82.2	133.2	126.8	183.9	111.1	151.7	106.7	156.2
LSD_{05}	7.6	8.1	6.9	6.1	3.0	9.3		

medial cuttings had a significant advantage. Over the three-year research period, the growth of three-node medial cuttings was 16.0 cm, which is 4.8 cm more than that of two-node medial cuttings by 7.7 cm – one-node. Three-node medial cuttings significantly prevailed over the same type of apical and basal cuttings throughout the study period. Analyzing the growth of the above-ground part of rooted single-node and two-node cuttings, it should be noted a significant advantage over the study period of two-node cuttings (Tab. 10).

In the cuttings harvested during the period of slow growth of the shoots, the largest increase in three-node apical cuttings is 5.3 cm, which is 1.6 times more than in the medial cuttings and 1.9 times more than in the basal ones.

Therefore, the optimal type for green *Viburnum* cuttings is a three-node cutting. If there is a shortage of material for grafting, double-knotted cuttings can be used.

In cuttings harvested during the period of slow growth of shoots, the growth of three-noded apical cuttings significantly exceeded those of the same type from the medial and basal parts of the shoot. It should be noted that there is no significant difference between the growth of rooted three-node medial and basal cuttings in 2020. During the period of research in single-node basal cuttings (Fig. 3).

Table 10. The influence of the type of cutting on the growth of cuttings of the Velikoplidna variety harvested during the period of intensive growth of shoots, cm

Type of cutting (number of nodes)	2020	2021	2022	Average for 3 years
Apical part				
1	4.9	3.1	6.1	4.8
2	7.1	6.3	9.2	7.5
3 (control)	11.9	10.1	12.4	11.4
Medial part				
1	7.7	7.1	10.2	8.3
2	10.5	10.2	13.0	11.2
3 (control)	16.1	14.9	17.0	16.0
Basal part				
1	1.5	0.9	0.5	0.9
2	3.1	3.2	2.1	2.8
3 (control)	6.1	5.8	5.6	5.8
LSD_{05}	2.7	0.7	0.6	

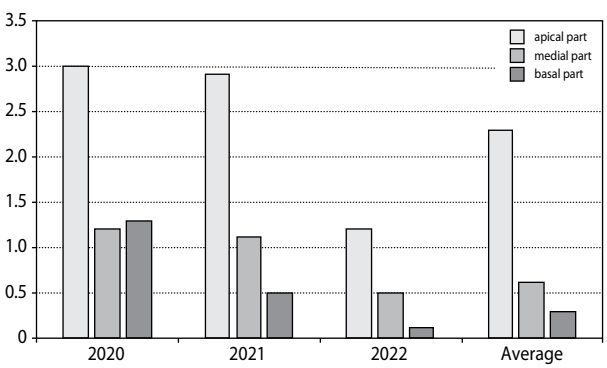

Figure 3. The influence of the type of cutting on the growth of cuttings of the Velikoplidna variety harvested during the period of slow growth of shoots, cm

There was no increase; only in 2020 was a slight increase recorded in medial ones, while the largest and significantly higher increase among this type of cuttings

was observed in apical cuttings. Therefore, the optimal type for *Viburnum* cuttings is a three-node cutting. If there is a shortage of material for grafting, double-knotted cuttings can be used.

Conclusions

A comparative analysis of the research data revealed that different methods of reproduction affect the rooting process of the Velikoplidna variety as follows:

1. The optimal type of scion for the Velikoplidna variety is three-noded.
2. The rooting and subsequent growth and development of rooted three-node cuttings of *Viburnum* of the ordinary Velikoplidna variety significantly outweigh similar indicators of two- and one-node cuttings.
3. If production requires, two-node cuttings can be used.
4. For the Velikoplidna variety, a single-node scion is insufficient for effective grafting.

References

Bakhmat, M. et al. 2023. Formation of the yield of *Matricaria recutita* and indicators of food value of *Sychorium intybus* by technological methods of cocultivation in the interrows of an orchard. *Journal of Ecological Engineering*, 24 (8), 250–259. DOI: 10.12911/22998993/166553.

Balabak, A.F. 2003. Root propagation of uncommon fruit and berry crops. Uman Operational Polygraphy.

Bulgakov, V. et al. 2023. Computer investigation of mineral fertiliser particle movement along centrifugal spreader disc inclined under angle to horizontal plane. *Engineering for Rural Development*, 22, 506–516.

Desurmont, G.A., Kerdellant, E., Pfingstl, T., Auger, P. 2019. Mites associated with egg masses of the Viburnum leaf beetle Pyrrhaltaviburni (Paykull) on *Viburnum tinus* L. *Acarologia*, 59 (1), 57–72. DOI: 10.24349/ acarologia/20194311.

Desurmont, G.A., Morelon, S., Benrey, B. 2020. First insights into the chemical ecology of an invasive pest: Olfactory preferences of the Viburnum leaf beetle (Coleoptera: Chrysomelidae). *Environmental Entomology*, 49 (2), 364–369. DOI: 10.1093/ee/nvaa007.

Desurmont, G.A., Weston, P.A. 2014. Switched after birth: Performance of the Viburnum leaf beetle *Pyrrhalta viburni* (Paykull) after transfer to a suboptimal host plant. *Insects*, 5 (4), 805–817. DOI: 10.3390/insects5040805.

Didur, I.M., Prokopchuk, V.M., Pantsyreva, G.V., Tsyganska, O.I. 2020. Recreational horticulture. Tutorial. VNAU, Vinnytsia.

Didur, I.M., Prokopchuk, V.M., Pantsyreva, H.V. 2019. Investigation of biomorphological and decorative characteristics of ornamental species of the genus *Lupinus* L. *Ukrainian Journal of Ecology*, 9 (3), 287–290.

Dubik V. Et al. 2024. Analysis and calculation of the dynamic voltage reserve of the converter when working under load in systems of subject regulation by electric drives of direct current. *Przeglad Elektrotechniczny*, 5, 117–123. DOI: 10.15199/48.2024.05.21.

Hetman, N., Veklenko, Yu., Petrychenko, V., Korniichuk, O., Buhaiov, V. 2024. Agrobiological substantiation of growing Hungarian vetch in mixed crops. *Scientific Horizons*, 27 (4), 61–75. DOI: 10.48077/scihor4.2024.61.

Hnatiuk, T.T., Zhitkevich, N.V., Petrychenko, V.F., Kalinichenko, A.V., Patyka, V.P. 2019. Soybean diseases caused by genus Pseudomonas phytopathenes bacteria**.** *Mikrobiologiceskij Zhurnal*, 81 (3), 68–83. DOI: 10.15407/microbiolj81.03.068.

Honcharuk, I. et al. 2022. Peculiarities of reproduction of *Pinus nigra* Arn. in Ukraine. *Bulletin of the Transilvania University of Braşov. Series II: Forestry, Wood Industry, Agricultural Food Engineering*, 15 (64), 33–42. DOI: 10.31926/but.fwiafe.2022.15.64.1.3.

Ivanyshyn, O., Khomina, V., Pantsyreva, H. 2021. Influence of fertilization on the formation of grain productivity in different-maturing maize hybrids *Ukrainian Journal of Ecology*, 11 (3), 262–269. DOI: 10.15421/2021_170.

Konstantinov, A.S., Prathapan, K.D., Vencl, F.V. 2018. Hiding in plain sight: Leaf beetles (Chrysomelidae: Galerucinae) use feeding damage as a masquerade decoy. *Biological Journal of the Linnean Society*, 123, 311–320. DOI: 10.1111/een.13096.

Lutkovska, S. 2020. Methodical approaches to evaluation of the processes of modernization of the environmental sustainable system. *Scientific Horizons*, 2, 111–118.

Maier, C.T. 2019. Range expansion of the Viburnum leaf beetle, *Pyrrhalta viburni* (Paykull, 1799) (Coleoptera: Chrysomelidae), in Connecticut. *Proceedings of the Entomological Society of Washington*, 121 (1), 54–62. DOI: 10.4289/0013-8797.121.1.54.

Matusiak, M. 2020. Evaluation of winter-resistance kinds of *Magnolia* L. in the conditions of the biostatsionar Vinnytsia National Agrarian University. *Scientific Horizons*, 3, 74–80. DOI: 10.33249/2663-2144-2020-88-3-74-80.

Matusyak, M.V., Pantsyreva, H.V., Prokopchuk, V.M. 2021. Assessment of decorative value and prospects of the genus *Magnolia* compositional use on the territory of Vinnytsia. *Agriculture and Forestry*, 4 (23), 137–147. DOI: 10.37128/2707-5826-2021-4-11.

Mazur, V., Didur, I., Tkachuk, O., Pantsyreva, H., Ovcharuk, V. 2021. Agroecological stability of cultivars of sparsely distributed legumes in the context of climate change. *Scientific Horizons*, 24 (1), 54–60. DOI: 10.48077/scihor.24(1).2021.54–60.

Mazur, V., Pantsyreva, H., Mazur, K., Myalkovsky, R., Alekseev, O. 2020. Agroecological prospects of using corn hybrids for biogas production. *Agronomy Research*, 18, 205–219. DOI: 10.15159/ar.20.016.

Mazur, V., Tkachuk, O., Pantsyreva, H., Demchuk, O. 2021. Quality of pea seeds and agroecological condition of soil when using structured water. *Scientific Horizons*, 24 (7), 53–60. DOI: 10.0.187.205/scihor.24(7).2021.53–60.

Mazur, V.A. et al. 2020. Photosynthetic productivity of potato plants depending on the location of rows placement in agrophytocenosis. *Ecology, Environment and Conservation*, 26 (2), 536–545.

Mazur, V.A., Pantsyreva, H.V., Mazur, K.V., Didur, I.M. 2019. Influence of the assimilation apparatus and productivity of white lupine plants. *Agronomy Research*, 17, 206–219.

Monarkh, V.V., Matusiak, M.V. 2020. Analysis of plant assortment in the greenhouse complex of Vinnitsia National Agrarian University as a key component of student training. *Ukrainian Journal of Ecology*, 10 (1), 192–198. DOI: 10.15421/2020_31.

Monarkh, V.V., Pantsyreva, H.V. 2019. Stages of the environmental risk assessment. *Ukrainian Journal of Ecology*, 9 (4), 484–492. https://doi.org/10.15421/2019_779.

Neyko, I., Matusyak, M., Neyko, O., Tsyhanska, O. 2023. Growth and breeding quality of English oak (*Quercus robur* L.) population in provenance tests in Vinnytsia region. *Bulletin of the Transilvania University of Braşov*, *Series II: Forestry, Wood Industry, Agricultural Food Engineering*, 16 (65), 1–16.

Neyko, I., Monarkh, V., Poznyakova, S., Matusiak, M. 2021. State of in situ forest genetic resources of broadleaved tree species in the Right-bank Forest-Steppe of Ukraine. *Folia Forestalia Polonica, Series A – Forestry*, 63 (2), 88–96. DOI: 10.2478/ffp-2021-0010.

Neyko, I., Yurkiv, Z., Matusiak, M., Kolchanova, O. 2019. The current state and efficiency use of in situ and ex situ conservation units for seed harvesting in the central part of Ukraine. *Folia Forestalia Polonica, Series A – Forestry*, 61 (2), 146–155. DOI: 10.2478/ffp-2019-0014.

Pantsyreva, G.V. 2019. The current state of the collection of peonies on the basis of the "Podillia" botanical garden of the Vinnytsia National Agrarian University. *Scientific Bulletin of NLTU of Ukraine*, 29 (8), 46–50. DOI: 10.36930/40290806.

Pantsyreva, H. 2021. Morphological and ecological-biological evaluation of the decorative species of the genus *Lupinus* L. *Ukrainian Journal of Ecology*, 9 (3), 74–77. DOI: 10.15421/2019_711.

Pantsyreva, H., Tysiachnyi, O., Matusyak, M., Kozak, Y. 2024. Influence of the type of root on the rooting of *Viburnum opulus*. *Journal of Ecological Engineering*, 25 (4), 238–248. DOI: 10.12911/22998993/184690.

Pantsyreva, H., Vovk, V., Bronnicova, L., Zabarna, T. 2023. Efficiency of the use of lawn grasses for biology and soil conservation of agricultural systems under the conditions of the Ukraine's Podillia. *Journal of Ecological Engineering*, 24 (11), 249–256. DOI: 10.12911/22998993/171649.

Pantsyreva, H.V., Myalkovsky, R.O., Yasinetska, I.A., Prokopchuk, V.M. 2020. Productivity and economical appraisal of growing raspberry according to substrate for mulching under the conditions of

Podilia area in Ukraine. *Ukrainian Journal of Ecology*, 10 (1), 210–214. DOI: 10.15421/2020_33.

Petrichenko, V.F., Kobak, S.Y., Chorna, V.M. 2017. Influence of inoculation and morphology of the regulator on the peculiarities of soybean plant growth in the forest-steppe. *Bulletin of Agricultural Science*, 11, 29–34.

Petrychenko, V.F. et al. 2018. Formation of the nitrogen-fixing potential and productivity of soybean varieties selected at the Institute of Feeds and Agriculture of Podillia of NAAS. *Mikrobiologiceskij Zhurnal*, 80 (5), 63–75.

Petrychenko, V., Korniychuk, O., Lykhochvor, V., Kobak, S., Pantsyrev, O. 2024. Study of sowing quality of soybean seeds depending on pre-sowing treatment of seed. *Journal of Ecological Engineering*, 25 (7), 332–339. DOI: 10.12911/22998993/188932.

Puyu, V. et al. 2021. Social-and-ecological aspects of forage production reform in Ukraine in the early 21st Century. *European Journal of Sustainable Development*, 10 (1), 221–228.

Snitynskyi, V. et al. 2023. Phytoremediation of 137Cs contaminated sod-podzolic soil in Northern Polissia white sweet clover (*Melilotus albus*). *International Journal of Environmental Studies*, 80 (5), 1–7. DOI: 10.1080/00207233.2023.2270305.

Titarenko, O., Ibatullin, I., Nedashkivskyi, V., Nedashkivska, N., Stepanchenko, V. 2022. Accumulation of Zn and Cu by cereal and leguminous vegetation under agrochemical improvement of natural fodder lands of the right bank forest steppe of Ukraine. *International Journal of Ecosystems and Ecology Science (IJEES)*, 12 (4), 245–250.

Tkach, O. et al. 2024. Influence of feeding area on development, productivity and nutritional value of chicory. *Agronomy Research*, 22 (1), 301–312. DOI: 10.15159/AR.24.001.

Tkachuk, O., Pantsyreva, H., Kupchuk, I., Volynets, Y. 2024. Soybean productivity in the forest-steppe of Ukraine under ecologization of cultivation technology. *Journal of Ecological Engineering*, 25 (5), 279–293. DOI: 10.12911/22998993/186494.

Vasylevskyi, O., Neyko, I., Yelisavenko, Y., Matusiak, M. 2021. Characteristics of natural oak forests of in se Khmilnytske lisove hospodarstvo and implementation of measures for their regeneration. *Scientific Horizons*, 24 (2), 37–46. DOI: 10.48077/scihor.24(2).2021.37-46.