BIOLOGY

BIOCHEMISTRY AND MOLECULAR BIOLOGY

Статья поступила в редакцию: 26.06.2026
Статья принята к публикации: 26.07.2026
Статья опубликована: 07.08.2026

УДК 634.22+634.1-15

DOI: 10.32743/UniChem.2026.146.8.23245

Effect of growth regulators and planting time on the rooting and survival of hardwood cuttings of stone-fruit clonal rootstocks

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Влияние регуляторов роста и сроков посадки на укоренение и приживаемость одревесневших черенков клоновых подвоев косточковых культур

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Abstract

This study examines in detail the propagation of promising clonal rootstocks of stone-fruit crops — the cultivars ‘Eureka 99’, ‘Myrobalan 29C’, ‘Fortuna’ and ‘Krymsky-5’ — by means of hardwood (lignified) cuttings, together with its efficiency. In the course of the field experiment, the influence of the biostimulant indole-3-butyric acid (IBA) and of a specialized callusing (kilchevanie) technique on the rooting parameters of the cuttings was comprehensively analyzed. It

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Библиографическое описание: Хайтбоев Б.Т. Влияние регуляторов роста и сроков посадки на укоренение и приживаемость одревесневших черенков клоновых подвоев косточковых культур // Universum: химия и биология : электрон. научн. журн. 2026. 8(146). URL: https://7universum.com/ru/nature/archive/item/23245

For citation: Khaitboev B.T. Effect of Growth Regulators and Planting Time on the Rooting and Survival of Hardwood Cuttings of Stone-Fruit Clonal Rootstocks // Universum: Chemistry and Biology : electronic scientific journal. 2026. No. 8(146). Available at: https://7universum.com/ru/nature/archive/item/23245

was established that the highest effect was obtained by treating the cuttings with IBA in autumn, followed by a specialized callusing process and planting in open ground in early spring. Under this treatment, rooting and survival rates reached 77.8–87.6 %, substantially exceeding the results of the other variants. On the basis of the scientific and practical conclusions obtained, this highly efficient method is deemed suitable for wide adoption in production, in order to raise high-quality, standard rootstocks in horticulture and nursery management.

Аннотация

В данном исследовании подробно изучен процесс размножения одревесневшими черенками перспективных клоновых подвоев косточковых плодовых культур — сортов «Эврика 99», «Миробалан 29С», «Фортуна» и «Крымский-5», а также его эффективность. В ходе научного эксперимента всесторонне проанализировано влияние биостимулятора индолилмасляной кислоты (ИМК) и специального метода кильчевания на показатели укоренения черенков. Установлено, что наивысший эффект обеспечила осенняя обработка черенков препаратом ИМК с последующим прохождением специального процесса кильчевания и высадкой в открытый грунт ранней весной. При этом показатели укореняемости и приживаемости достигли 77,8–87,6 %, что существенно превышает результаты других вариантов. На основании полученных научно-практических выводов данный высокоэффективный метод признан целесообразным для широкого внедрения в производство с целью выращивания высококачественных и стандартных подвоев в сфере садоводства и питомниководства.

Keywords: clonal rootstocks, stone-fruit crops, vegetative propagation, hardwood cuttings, indole-3-butyric acid (IBA), callusing (kilchevanie), rooting rate, survival rate, biometric parameters.

Ключевые слова: клоновые подвои, косточковые культуры, вегетативное размножение, одревесневшие черенки, индолилмасляная кислота (ИМК), кильчевание, степень укореняемости, биометрические показатели.

Introduction

In modern fruit growing, the use of vegetatively propagated clonal rootstocks is an urgent task in establishing intensive orchards. Clonal rootstocks ensure uniform growth of trees, early onset of cropping, and good adaptability to soil-and-climate conditions. However, the low rooting percentage obtained when many valuable rootstock types — particularly those intended for stone fruits — are propagated by the conventional hardwood-cutting method remains one of the main problems.

In plant physiology, growth regulators of the auxin group, including indole-3-butyric acid (IBA), are widely used to stimulate root formation. At the same time, the rooting process depends not only on an externally applied growth regulator but also on the internal resources of the cutting — its diameter and its position on the mother plant. The aim of the present study was to determine, for various clonal rootstocks, the optimal combination of an appropriate IBA rate and cutting diameter.

It has been reported that in rootstocks of the genus Prunus the IBA concentration is the principal factor activating root formation; however, an individual optimal rate exists for each genotype, and concentrations above the optimum inhibit regeneration [1, 4]. In particular, the rootstocks of the ‘Krymsk’ series have been shown to be highly sensitive to external chemical treatments [5, 10, 11].

Studies on the morpho-physiological characteristics of the cutting confirm that cuttings prepared from the lower part of the shoot and of sufficient diameter provide higher stability in rooting owing to their higher content of reserve carbohydrates [2, 3, 9]. It has also been scientifically substantiated that soaking the basal part of the cuttings in an auxin solution is the most effective agronomic practice for production [6, 8].

Research site and conditions

The studies were carried out at the experimental field of the Research Institute of Horticulture, Viticulture and Winemaking named after Academician Mahmud Mirzaev. The soil of the site is a typical irrigated grey (sierozem) soil. It contains from 19.0 to 23.0 % carbonates, has a pH of 7.1, a weak structure and a tendency to compaction. According to the mechanical composition of the parent material, the soil of the experimental field is unstable and consists of medium and heavy loams. Because of the low content of humus and colloidal particles, the soil has a weak and fragile structure. The groundwater lies at a depth of 20–30 m below the soil surface.

The climate of the experimental field is distinguished by its abundance of heat and light, as well as by its dryness. The mean annual amplitude of air temperature is +28…+30 °C, and the absolute amplitude of air temperature is 75–80 °C. Summers are hot and dry, with an absolute maximum reaching +44 °C. Autumn is long and warm; the first autumn frost is observed on 3 October. Winter is unstable, with abrupt transitions from warm to cold. The mean monthly temperature in January is −0.4 °C, and the absolute minimum is −30 °C. The probability of a winter with a minimum air temperature of −15 °C is 75 %, of −20 °C is 15 %, and of −25 °C only 10 %. Spring is characterized by markedly variable air temperatures. The frost-free period averaged 203 days.

Materials and methods

Cuttings 18–22 cm long were prepared by cutting one-year-old shoots from mother plantations of the rootstocks at different dates; cuttings were separated from the basal (lower, 6–9 mm), middle (4–6 mm) and apical (upper, 2–4 mm) parts of the shoots.

The application rates of the root-promoting growth regulator indole-3-butyric acid (IBA) tested were: soaking the cuttings in water before planting (control); 45 mg/L; 60 mg/L; 75 mg/L; 90 mg/L; and 110 mg/L IBA.

The most suitable dates and methods for the sprouting of hardwood cuttings of the vegetative rootstocks for stone fruits were tested as follows:

First method: cuttings were prepared from one-year-old shoots of the rootstocks in autumn, in the third decade of November, soaked in water, buried in soil and stored in trenches until early spring, then planted in the first decade of March (control).

Second method: cuttings were prepared in autumn (third decade of November), treated with the selected growth regulator (IBA) at 75–90 mg/L, buried in soil, stored in trenches until early spring, and planted in the first decade of March.

Third method: cuttings were prepared in autumn (third decade of November), treated with IBA at 75–90 mg/L, buried in soil and stored in trenches until early spring; in the second decade of February the cuttings were dug out of the trenches, arranged with the treated (basal) ends facing upward, covered with a 5–10 cm layer of a 1:1 mixture of rotted manure and soil for callusing (kilchevanie), and planted in the first decade of March.

Fourth method: cuttings were prepared in autumn (third decade of November), treated with the optimal rate of the growth regulator, and planted directly.

Fifth method: in the last decade of February, cuttings were prepared from one-year-old shoots of the vegetative rootstocks and, after treatment with the selected rate of the growth regulator, were arranged with the treated ends facing upward, covered with a 5–10 cm layer of a 1:1 mixture of rotted manure and soil (callusing), and planted in the first decade of March.

The following planting schemes were tested for the stone-fruit rootstocks: 70 × 20 cm (control); 70 × 15 cm; and 70 × 10 cm. In each variant of the experiment, 1000 cuttings of each rootstock were planted in four replications.

Results and discussion

Analysis of morpho-biological changes among the rootstocks. Eureka 99 rootstock. In this clonal rootstock the survival rate in the control variant was 59.0%, whereas in the optimal variant using IBA together with callusing it rose to 87.6% (28.6% higher than the control). The total plant height increased from 72.7 cm in the control to 84.6 cm, and the number of leaves — which determines the photosynthetic and assimilation surface — rose from 98.2 to 113.3. In the variant treated with IBA in autumn and planted directly, plant height was the highest (87.3 cm), yet the survival rate (63.5%) lagged well behind the callused variant.

Myrobalan 29C rootstock. The same regularity was repeated in this rootstock: instead of the 55.5% survival of the control, the advanced technology (IBA + callusing + spring planting) recorded 86.8%. In this variant, the mean shoot length increased from 14.5 cm in the control to 16.7 cm. The IBA stimulant, by mobilizing the reserve nutrients of the cutting, ensured the balanced development of the above-ground and below-ground parts.

Fortuna and Krymsky-5 rootstocks. Owing to the specific biological characteristics of these rootstocks, their total height and shoot length recorded somewhat lower values than in Eureka 99; nevertheless, a proportional positive gain relative to the control was maintained. The survival of the Fortuna rootstock rose from 55.0% in the control to 79.7% under the effect of IBA and callusing. In the Krymsky-5 rootstock this indicator increased from 55.2% to 77.8%, and the rise in leaf number from 60.3 in the control to 72.4 directly reflected the activation of organic-matter synthesis in the plant and the future formation of healthy planting stock.

The variants of autumn IBA treatment followed by burial or direct planting also showed a marked advantage over the control, but did not provide the stable, maximum survival attained in the callused variant. In turn, although the method of cutting in spring, treating with IBA and callusing likewise gave fairly good results (for example, 72.6 % in Eureka 99), it did not reach the efficiency of the autumn treatment (87.6 %). This indicates that the entry of the cuttings into winter dormancy and their gradual physiological preparation under the influence of IBA proceed more effectively at the autumn date.

The mathematical reliability of the statistical analyses is fully confirmed by the small values of the LSD (least significant difference) given at the end of the table (0.5–1.8 cm for height and length, and 2.1–2.8 % for survival rate).

Table 1.

Development of the crown of hardwood cuttings planted in a 70 × 15 cm scheme (with IBA applied at 75 mg/L), 2018–2020

Rootstock	Planting time / method	Plant height, cm	Shoots, pcs	Mean shoot length, cm	Leaves, pcs	Survival, %
Eureka 99	Autumn — soaked in water, buried, planted in spring (control)	72.7	3.9	19.5	98.2	59.0
	Autumn — treated with IBA, buried, planted in spring	88.4	4.3	24.2	117.6	70.4
	Autumn — treated with IBA, callused, planted in spring	84.6	4.1	23.3	113.3	**87.6**
	Autumn — treated with IBA, planted directly	87.3	4.6	25.4	118.2	63.5
	Spring — cut, treated with IBA, callused, planted	75.7	3.9	21.2	107.3	72.6
Myrobalan 29C	Autumn — soaked in water, buried, planted in spring (control)	66.4	3.1	14.5	68.6	55.5
	Autumn — treated with IBA, buried, planted in spring	74.3	3.6	16.1	94.7	73.6
	Autumn — treated with IBA, callused, planted in spring	77.4	3.5	16.7	95.6	**86.8**
	Autumn — treated with IBA, planted directly	78.3	3.8	17.8	97.4	70.1
	Spring — cut, treated with IBA, callused, planted	73.7	3.2	15.6	90.3	77.6

Rootstock	Planting time / method	Plant height, cm	Shoots, pcs	Mean shoot length, cm	Leaves, pcs	Survival, %
Fortuna	Autumn — soaked in water, buried, planted in spring (control)	44.3	3.1	11.2	51.3	55.0
	Autumn — treated with IBA, buried, planted in spring	55.4	3.6	14.4	63.4	72.2
	Autumn — treated with IBA, callused, planted in spring	56.7	3.8	16.1	67.3	**79.7**
	Autumn — treated with IBA, planted directly	55.3	3.2	13.2	60.3	64.0
	Spring — cut, treated with IBA, callused, planted	50.2	3.4	13.6	55.7	74.3
Krymsky-5	Autumn — soaked in water, buried, planted in spring (control)	55.6	3.6	13.3	60.3	55.2
	Autumn — treated with IBA, buried, planted in spring	64.4	4.1	17.6	68.5	68.4
	Autumn — treated with IBA, callused, planted in spring	67.8	4.4	19.3	72.4	**77.8**
	Autumn — treated with IBA, planted directly	64.7	4.1	16.5	67.3	51.3
	Spring — cut, treated with IBA, callused, planted	60.3	3.8	15.4	63.4	69.3
LSD_{05}	*1.4*	—	*0.5*	—	*1.8*	
LSD, %	*2.1*	—	*2.8*	—	*2.6*	

Note: In each variant, 1000 cuttings of each rootstock were planted in four replications. The highest survival values (callused variant) are shown in bold.

Conclusions

1. In the process of vegetative propagation of clonal rootstocks intended for stone-fruit species (Eureka 99, Myrobalan 29C, Fortuna, Krymsky-5), a sharp increase in the morpho-biological and biometric indicators of the plants was recorded under the influence of the indole-3-butyric acid (IBA) stimulant compared with the control (water soaking) variant.

2. Among all the variants tested, the highest agronomic efficiency was scientifically substantiated to be achieved by the technology of stimulating the cuttings with an IBA solution in autumn, callusing (kilchevanie) them with the aid of artificial bottom heat, and planting them in spring. Under this optimal method, the survival rate of the rootstocks was high, ranging from 77.8 % to 87.6 %.

3. Under the combined effect of the callusing process and the IBA stimulant, the total height of the rootstock plants, the number of shoots and their mean length increased significantly more intensively than in the control variant. In particular, an expansion of the assimilation apparatus (leaf number) and vigorous development of the above-ground part were recorded in the Eureka 99 and Myrobalan 29C rootstocks.

4. The developmental dynamics of cuttings that were cut and treated with IBA in spring were lower than those of cuttings prepared in autumn. This showed, and was confirmed during the study, the important role of the autumn dormancy period and of the physiological-biochemical changes occurring under the influence of the stimulant in the formation of a strong root system in the cuttings.

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