Development of Technology for Growing Seedlings of Local Citrus Varieties

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Abstract. The study presents the development of an innovative technology for propagating seedlings of local citrus varieties—lemon, orange, and mandarin—using the biopolymer-based preparation **UZKHITAN**. This preparation, a polymer mixture of chitin and carboxymethyl cellulose, was applied to citrus cuttings to enhance rooting efficiency under controlled conditions. Experimental results demonstrated that treatment with UZKHITAN significantly accelerated the rhizogenesis process and improved the rooting percentage of citrus cuttings compared to conventional stimulants. The highest rooting rates (91–94%) were observed in lemon cultivars *F-1 Tashkent* and *F-2 Yubileiny*, while orange and grapefruit–pomelo hybrids showed moderate rooting (34–37%), and mandarin cuttings exhibited the lowest rate (22%). The optimal treatment duration was found to be 5 minutes, resulting in callus formation on days 9–10 and complete rooting within 25–28 days. This method reduces the rooting period nearly by half compared to traditional heteroauxin treatment. The study concludes that encapsulating citrus cuttings in UZKHITAN prior to planting provides a highly effective, eco-friendly, and economically feasible propagation technology for citrus crops in Uzbekistan. This approach enables the year-round production of high-quality planting material, maintains varietal purity, and ensures early fruiting, thereby contributing to the development of intensive citrus cultivation and the achievement of the national agricultural goals outlined in the *Strategy for the Development of New Uzbekistan (2022–2026)*.

Keywords: citrus propagation; UZKHITAN; rooting stimulants; lemon; mandarin; orange; biopolymer encapsulation; seedling technology; root formation; Uzbekistan horticulture

1 Introduction

Citrus fruit plants occupy an important place in the global food industry. They are used not only for fresh fruit production but also for juices, jams, essential oils, and other products. Citrus crops are resistant to drought, high temperatures, and certain pests, which makes their cultivation relatively convenient under changing climatic conditions.

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Worldwide, 146,866,263 tons of citrus fruits are produced annually. China is considered the largest citrus producer in the world, producing 38,392,847 tons per year, followed by Brazil with 19,591,623 tons, and India with 12,043,000 tons. In terms of yield per hectare, the top three countries are Turkey (31.6 t/ha), Brazil (25.7 t/ha), and China (14.6 t/ha)[1]. Currently, improving technologies for citrus cultivation in protected environments and increasing productivity remain pressing issues.

In countries such as China, India, Brazil, Turkey, and the USA, scientific research is conducted to expand the range of citrus crops, develop frost-resistant varieties for open-field cultivation, and increase yields using resource-saving technologies. The implementation of modern cultivation technologies—such as optimization of planting schemes, pruning and shaping, and the use of efficient irrigation and fertilization methods—contributes to the annual increase in citrus fruit production [4-12].

In the Republic of Uzbekistan, special attention is given to increasing the production of nutrient-rich and medicinal fruits, such as lemon, orange, mandarin, and grapefruit [2]. Numerous studies have been conducted on cultivating high-yield, export-oriented citrus crops both in open fields and unheated greenhouses, achieving certain results. However, there is still a lack of contemporary research on intensive citrus cultivation and yield improvement.

In the *Strategy for the Development of New Uzbekistan for 2022–2026*, item 30, dedicated to agriculture, one of the priority tasks is stated as: "…production of export-oriented products and development of horticulture, tripling the area of intensive orchards and doubling greenhouse areas, as well as increasing export potential by an additional 1 billion USD"[2].

In this regard, conducting scientific and practical research on expanding varietal diversity under protected cultivation, studying agrobiological characteristics, propagation methods, intensive cultivation technologies, and determining the biochemical composition of fruits is highly relevant.

The Presidential Decree of the Republic of Uzbekistan dated March 6, 2018, No. UP-3586 "On Additional Measures for the Further Development of Lemon Cultivation in the Republic of Uzbekistan" and the Decree dated February 19, 2020, No. UP-4610 "On Additional Measures for the Further Development of the Lemon Industry," along with tasks outlined in related regulatory acts, serve as the scientific basis for activities in this field.

The Presidential Resolution on additional measures to expand food production and fill the domestic market emphasizes the need to ensure stable food supply for the population, comprehensively satisfy domestic consumer demand with local products, accelerate the establishment of modern compact processing enterprises equipped with high-performance machinery and technologies—primarily in rural areas—and create new jobs, increase employment, income, and overall well-being. Citrus plants are not only essential food crops but also a significant source of economic benefit. On December 1, 2024, under the chairmanship of President Sh. Mirziyoyev, a meeting was held on increasing production, processing, and export of horticultural and vegetable products. At least 100 lemon and grape seedlings will be distributed per household in each neighborhood. Currently, the total area of lemon orchards in Uzbekistan exceeds 2,321 hectares, with an annual lemon harvest of 63,000 tons and an export potential of 11,000 tons. Average yield in lemon orchards is 55–60 tons per hectare.

2 Materials and methods

Citrus fruit plants occupy an important place in the global food industry. They are used not only for fresh fruit production but also for juices, jams, essential oils, and other products. Citrus crops are resistant to drought, high temperatures, and certain pests, which makes their cultivation relatively convenient under changing climatic conditions. Worldwide, 146,866,263 tons of citrus fruits are produced annually. China is considered the largest citrus producer in the world, producing 38,392,847 tons per year, followed by Brazil with 19,591,623 tons, and India with 12,043,000 tons. In terms of yield per hectare, the top three countries are Turkey (31.6 t/ha), Brazil (25.7 t/ha), and China (14.6 t/ha)[1]. Currently, improving technologies for citrus cultivation in protected environments and increasing productivity remain pressing issues.

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Table 1. Rooting Ability and Phenophases of Root Formation in Citrus Cuttings (Average for 2019–2024)

Type and Variety	Rooting Percentage (%)	Onset of Callus For-mation (days)	Mass Root Formation (days)	Onset of Shoot Growth (days)
Lemon F-2 Yubileiny	91,0 ±2,8	9-10	23-24	20-21
Lemon F-1 Tashkent	94,0 ± 2,4	9-10	25-25	23-24
Orange Uzbekistan	34,1 ±4,7	13-14	36-37	29-31
Grapefruit–Pomelo hybrid “Zayniddin”	37,0 ± 4,8	12-13	40-41	31-32
Mandarin “Tashkent”	22,3 ±4,1	15- 16	44-45	34-35
HCP05	1,07			

3 Results

The results of the study demonstrated that the highest rooting percentage, ranging from 91% to 94%, was observed in encapsulated cuttings immersed for 5 minutes in the growth stimulant UZKHITAN. This effect was most pronounced in green cuttings of lemon cultivars F-1 Tashkent and F-2 Yubileiny. The average rooting percentage, ranging from 34.1% to 37.0%, was found in cuttings of the orange cultivar Uzbekistan and the grapefruit–pomelo hybrid Zayniddin. Comparatively low rooting (22.3%) was observed in mandarin cuttings of the Tashkent cultivar.

The rooting rate was largely dependent on the intensity and duration of rhizogenesis phases [1]. In lemon cuttings, callus formation began on the 9th–10th day, mass rooting on the 23rd–25th day, and shoot growth was recorded on the 20th–24th day. In contrast, the process in orange, grapefruit, and mandarin cuttings was significantly slower, occurring on the 12th–16th, 36th–45th, and 29th–35th days, respectively.

To accelerate root formation under greenhouse conditions, the cuttings should be encapsulated in UZKHITAN for 5 minutes and planted in special nurseries with fertile soil. Under these conditions, root clusters appear within 25–28 days, producing viable seedlings. Depending on the number of cuttings, a trench 20 cm deep and 80 cm wide is prepared in the greenhouse or in a specially designated area. The trench is reinforced with wooden planks to prevent the sidewalls from collapsing. A 2–5 cm layer of small pebbles is placed for drainage, followed by a 6 cm layer of humus and a 20 cm layer of

coarse sand. The surface is leveled, and the cuttings, previously rinsed in clean water, are planted to a depth of 2 cm in a 5×5 cm pattern. The air temperature should be maintained between +18°C and +25°C, and the relative humidity within 70–80%.

After planting, the cuttings are covered tightly with polyethylene film, fixed securely at the bottom. To promote faster root development, seven days after planting, the lower part of the bed is irrigated daily with water mixed with soil, taking care not to wet the leaves. During irrigation, the film is opened daily for ventilation, then closed smoothly and sprayed evenly with water three times a day. After 10–12 days, callus tissue begins to appear, and after 25–28 days, roots begin to form. During this period, regular irrigation and periodic ventilation are essential. Before transplanting the rooted seedlings to a permanent site, the film is left open for several days for acclimatization.

Under the climatic conditions of Uzbekistan, such propagation can be carried out throughout the year, producing standard seedlings on a monthly basis. However, during the winter period, additional heating and lighting are required. Seedlings encapsulated with UZKHITAN develop a dense, well-branched root system.

This propagation method, developed by scientists of the Tashkent State Agrarian University, has proven effective in accelerating root formation in lemon, orange, and mandarin seedlings. Planting encapsulated cuttings pretreated with UZKHITAN for 5 minutes is currently considered a modern and advanced propagation technique.

These results were achieved through the support of People's Academician Z. Fakhruddinov. Vegetative propagation by such cutting techniques allows the expansion of high-yielding citrus cultivars while maintaining their genetic characteristics. The resulting seedlings begin to bear fruit in the second or third year and produce abundant annual yields.

This simplified propagation method enables the year-round production of standard seedlings. Previously, a 0.01% heteroauxin solution was used for root stimulation, resulting in root cluster formation within 50–60 days. The application of UZKHITAN significantly shortens this period, almost by half.

In specially prepared beds, a 5 cm layer of small stones is placed for drainage, followed by 6 cm of organic–mineral fertilizer, and 20 cm of coarse sand treated with a potassium permanganate solution. The cuttings are planted at a depth of 2 cm according to a 5×5 cm spacing pattern. To maintain uniform temperature and humidity, the bed is sealed with polyethylene film, which is sprayed with water three times daily until root formation.

To further accelerate rooting, once a week the cuttings are irrigated with a 50% aqueous solution of UZKHITAN. The film is opened daily for 5–10 minutes for ventilation, followed by overhead watering, and then closed again.

According to Table 2, callus formation begins on the 10th day, primary roots appear by the 18th–20th day, and by the 23rd–28th day, the cuttings develop a full root system, transforming into well-established seedlings ready for transplantation.

Table-2. Accelerated Planting of Subtropical Plant Seedlings by Cutting Propagation Method

Experimental Variants	Citrus Plant Varieties	Stages of Cutting Development				Stages of Root Formation	
		Beginning of Root Formation (day)	Beginning of Root Emergence (day)	Process of Complete Rooting (day)	Completion of Rooting Process (day)	Percentage of the 4-stage Reversion of the Rooting Process	Compared to the Control
Water (control)	Lemon F-1	10.0	23	50-60	32-36	81.0	1200 +540 -660
	Lemon F-2	10.0	23.0	50-60	24-25	85.0	
	Orange	13.0	40.0	59-60	40-41	8,3	
	Mandarin	15.0	45.0	65-70	45-50	4,6	
UZKHITAN	Lemon F-1	8.0	18.0	24-25	25-26	98.0	1200 +751 -449
	Lemon F-2	8.0	17.0	23-24	25-26	98.0	
	Orange	9.0	18.0	27-28	23-24	45.0	
	Mandarin	12.0	24.0	30-31	26-28	14.0	
AHZ (4:1)	Lemon F-1	9.0	19.0	25-26	26-27	89,3	1200 +711 -489
	Lemon F-2	9.0	18.0	24-25	27-28	86	
	Orange	11.0	21.0	28-29	25-26	41	
	Mandarin	13.0	25.0	35-36	28-29	20,6	
0.01% heteroauxin solution	Lemon F-1	9.0	19.0	26-27	27-28	87.0	1200 +700 -500
	Lemon F-2	9.0	21.0	24-25	24-25	96.0	
	Orange	12.0	22.0	28-29	25-26	32.0	
	Mandarin	14.0	35.0	47.0	25-26	20.3	

Thus, it can be noted that citrus crops possess a high rooting ability when using encapsulated cuttings immersed for 5 minutes in the preparation UZKHITAN**.** It should be emphasized that UZKHITAN, as a growth stimulant, has not yet been widely introduced into agricultural practice and, in citrus cultivation, is still applied mainly under laboratory conditions. at present, it is considered an innovative method [3].

4 Conclusion

1. The biological activity of UZKHITAN in the encapsulation of citrus cuttings has been identified. It has been shown that the pre-sowing treatment of citrus

cuttings with UZKHITAN solutions contributes to an increase in root formation, and at the same time, the period of root emergence is almost halved due to the use of UZKHITAN stimulants. The possibility of replacing the domestic preparation "UZKHITAN" with a water-soluble, film-forming AHZ (4:1) has been demonstrated, which will allow obtaining healthy seedlings and increasing yield in the future.

2. UZKHITAN 2% WP (wettable preparation) is recommended for citrus crops (lemon, orange, mandarin, and grapefruit) to accelerate root system development at a rate of 200 ml per 1,000 cuttings, and for vegetable and melon crops as a seed treatment agent against root rot at a rate of 20 L per ton of seeds**.**
3. To obtain the highest quality planting material of citrus crops, the cuttings should be treated with the UZKHITAN preparation for 5 minutes before planting.
4. The planting of encapsulated cuttings immersed for 5 minutes in the UZKHITAN preparation is currently considered the most advanced and innovative propagation method.

Disclosure of Interests. The authors have no competing interests to declare that are relevant to the content of this article.

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