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SCIENTIFIC FOUNDATIONS OF SUSTAINABLE GREENHOUSE PRODUCTION OF NEW STRAWBERRY CULTIVARS

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Abstract

This study evaluated in vitro propagation, sterilization efficiency, acclimatization, greenhouse performance, and economic feasibility of strawberry (Fragaria × ananassa) genotypes including “Tong ifori”, K-83, and M-11. The ethanol + NaOCl treatment showed the highest sterilization efficiency (90% viability, 5% contamination). “Tong ifori” demonstrated the highest multiplication rate (15.8%), with a total production of 12.5 thousand plantlets. Coconut peat provided the best acclimatization results (96.7% survival), while micronutrient (B, Zn, Mn) supplementation enhanced vegetative growth and root development. Economic analysis revealed a total revenue of 88,000,000 UZS and production costs of 47,000,000 UZS, resulting in a net profit of 41,000,000 UZS. The profitability level was approximately 72.0%, confirming the economic efficiency and viability of the proposed production system. Overall, integrated application of optimized sterilization, micropropagation techniques, suitable substrates, and micronutrient management significantly improves strawberry plantlet production, establishment, and economic performance under controlled conditions.

Keywords: strawberry, agrotechnology, *in vitro*, plant, seedling, cassette, mother plants, mother nursery, greenhouse, rack system, hydroponics, yield, training manual, recommendations.

Introduction. Strawberry (*Fragaria × ananassa* Duch.) is one of the most economically valuable berry crops worldwide because of its high nutritional value, consumer demand, and adaptability to diverse production systems. According to the FAOSTAT database, global strawberry production has increased remarkably over the last decades, reaching more than 10 million tons with a harvested area exceeding 430 thousand hectares. Continuous growth in both cultivated area and productivity reflects the increasing importance of strawberry cultivation for global food security, sustainable horticulture, and the fresh fruit market (FAO, 2025).

In addition to its economic importance, strawberry (*Fragaria × ananassa* Duch.) is widely recognized as a functional food because of its exceptional nutritional and health-promoting properties. Strawberry fruits are rich sources of vitamin C, folates, dietary fiber, potassium, and essential minerals, as well as a wide range of bioactive phytochemicals, including anthocyanins, flavonoids, phenolic acids, tannins, and ellagic acid. These compounds exhibit strong antioxidant activity and contribute significantly to the prevention of oxidative stress in the human body.

Numerous scientific studies have demonstrated that regular strawberry consumption is associated with a reduced risk of several chronic diseases, including cardiovascular disorders, type 2 diabetes, obesity, and certain types of cancer. The high concentration of anthocyanins and other polyphenolic compounds helps reduce inflammation, improve endothelial function, regulate blood glucose levels, and protect cells against free radical damage. Furthermore, strawberries have been reported to support immune function, promote healthy aging, and contribute to gastrointestinal health through their fiber content and beneficial phytochemicals.

The increasing awareness of the relationship between diet and human health has led to a growing global demand for high-quality strawberry fruits with enhanced nutritional value. Consequently, modern strawberry breeding programs are not only focused on improving yield and adaptability but also on enhancing fruit quality traits, including antioxidant capacity, bioactive compound accumulation, flavor, aroma, and postharvest shelf life. The development of cultivars combining superior agronomic performance with improved nutritional characteristics has therefore become an important objective of sustainable strawberry production systems.

Literature Review. The rapid expansion of strawberry production has stimulated intensive breeding activities aimed at developing cultivars with improved yield, fruit quality, resistance to biotic and abiotic stresses, and adaptation to different agro-climatic environments. Currently, more than forty active strawberry breeding programs operate worldwide, with the largest concentration found in North America and Europe, although substantial progress has recently been observed in Asian countries, particularly China (Chandler *et al*., 2012). These breeding efforts have significantly contributed to the release of cultivars specifically adapted to regional production systems.

One of the world's most influential breeding programs is that of the University of California, which has played a key role in the development of low-chilling strawberry cultivars. Over several decades, this program has released commercially successful cultivars, including ‘Tioga’, ‘Aliso’, ‘Sequoia’, ‘Toro’, ‘Pajaro’, ‘Douglas’, ‘Chandler’, ‘Camarosa’, ‘Ventana’, and ‘Albion’, followed by the day-neutral cultivars ‘Monterey’, ‘Portola’, and ‘San Andreas’. Among these, ‘Albion’ and ‘San Andreas’ remain dominant cultivars due to their extended fruiting period and excellent commercial performance.

Recent breeding achievements in California include the June-bearing cultivars ‘Benicia’ and ‘Mojave’, which represent current breeding priorities focused on early maturity, superior fruit quality, simplified crop management, and lower harvesting costs through controlled vegetative growth.

In parallel with public institutions, private breeding companies have become increasingly important contributors to strawberry genetic improvement. Proprietary cultivars developed by organizations such as Driscoll's Strawberry Associates, Plant Sciences, and Berry Genetics occupy a substantial proportion of California's commercial production area. Through international breeding networks and protected "club variety" systems, these companies develop cultivars adapted to a wide range of environmental conditions across North and South America, Europe, Africa, and Australia. Commercially important cultivars originating from these programs include ‘Alafia’, ‘Amado’, ‘Del Rey’, ‘El Dorado’, ‘Pasadena’, ‘Pilgrim’, and ‘San Juan’.

Since the mid-1980s, Plant Science Inc. has focused on breeding early-ripening cultivars with low chilling requirements suitable for mild climates. This program has produced several successful cultivars, including ‘Promise’, ‘Splendor’, ‘Valor’, and ‘Virtue’. Among these, ‘Splendor’ gained particular importance in the Huelva region of Spain, where it rapidly became one of the principal commercial cultivars.

The Florida strawberry breeding program has adopted a different strategy by concentrating on the development of cultivars capable of producing high-quality fruit during the winter season under relatively low temperatures and frequent rainfall. This program led to the release of ‘Florida Festival’, which has become commercially important in many strawberry-producing regions worldwide. Another notable achievement is ‘Florida Radiance’, marketed in Europe as ‘Florida Fortuna’, which is highly valued for its exceptionally early fruit production and successful adaptation to Mediterranean growing conditions.

Outside North America, significant breeding initiatives are also being conducted in Australia and Europe. In Australia, the University of Queensland and Horticulture and

Forestry Science have developed cultivars adapted to subtropical environments, with 'Kalinda' representing one of the latest day-neutral releases. In Spain, both public and private breeding programs have generated numerous commercially important cultivars (Della Strada and Fideghelli, 2011). The IFAPA breeding initiative has released 'Amiga', 'Santaclara', and 'Fontanilla', while private organizations such as Fresas Nuevos Materiales and Planasa have developed cultivars including 'Antilla', 'Primoris', 'Niebla', 'Sabrosa', 'Sabrina', 'Sahara', 'Safari', and 'Cristal'.

French breeding programs have also made significant contributions to global strawberry improvement. The Marionnet program developed the aromatic cultivar 'Mara des Bois', followed by 'Mariguette' and 'Magnum', whereas the Darbonne-Planasa collaboration introduced successful cultivars such as 'Darselect', 'Dream', 'Deluxe', 'Starlette', and the day-neutral cultivar 'Amandine'.

Overall, the continuous expansion of international strawberry breeding programs demonstrates the growing importance of genetic improvement for sustainable strawberry production. Current breeding strategies increasingly emphasize early fruiting, enhanced fruit quality, adaptation to protected cultivation systems, resilience to environmental stresses, and the development of cultivars suitable for sustainable and climate-resilient horticultural production systems.

Strawberry breeding activities have expanded worldwide, with numerous public and private institutions focusing on the development of cultivars adapted to different climatic conditions and production systems. In Florida (USA), breeding efforts are primarily aimed at producing cultivars with extremely low chilling requirements that are capable of fruiting during the winter season. The program emphasizes stable yield, uniform fruit shape, and adaptability to the cool and humid conditions that frequently occur in the region. One of its major achievements was the release of 'Florida Festival', while the later cultivar 'Florida Radiance', commercially known in Europe as 'Florida

Fortuna', gained widespread popularity because of its very early ripening and excellent adaptation to Mediterranean environments.

In Australia, breeding programs conducted by the University of Queensland and Horticulture and Forestry Science are dedicated to developing cultivars suitable for subtropical production systems. Among their recent achievements is the day-neutral cultivar 'Kalinda'. Additional breeding activities in the state of Victoria are directed toward improving adaptation to the environmental conditions of southern Australia.

Spain has established several important strawberry breeding initiatives. The IFAPA breeding program, supported through public-private cooperation, focuses on developing improved early cultivars for the winter production systems of the Huelva region. Cultivars such as 'Amiga', together with the more recent 'Santaclara' and 'Fontanilla', represent the outcomes of this program. Private companies also contribute significantly to Spanish strawberry improvement. Fresas Nuevos Materiales (FNM) has introduced cultivars including 'Antilla', 'Primoris', and 'Niebla', whereas Planasa achieved international recognition with 'Sabrosa'. More recently, the company released 'Sabrina', 'Sahara', 'Safari', and the day-neutral cultivar 'Cristal', several of which have become commercially important in Mediterranean production areas (Domínguez et al., 2012)..

French breeding programs have also made substantial contributions to strawberry improvement. The Marionnet program developed the highly aromatic cultivar 'Mara des Bois', followed by 'Mariguette' and 'Magnum', which retain similar fruit quality characteristics. Another French initiative, CIREF, focuses on producing short-day and day-neutral cultivars with superior eating quality, resulting in the release of 'Rubis Des Jardin'. In collaboration with Planasa, the Darbonne breeding program has generated cultivars adapted to Central and Northern Europe, including 'Darselect', 'Dream', 'Deluxe', 'Starlette', and the day-neutral cultivar 'Amandine' (Roudeillac and Markocic, 1997).

In the United Kingdom, the historical East Malling breeding program has produced a number of commercially valuable cultivars, including ‘Serenity’, ‘Malling Centenary’, and ‘Buddy’. A separate private breeding effort by Edward Vinson Plants has concentrated on ever-bearing cultivars, leading to the development of ‘Everest’, ‘Evie 2’, ‘Sweet Eve’, ‘Velvet’, ‘Verity’, and ‘Viva Patricia’.

The Netherlands remains one of the leading countries in strawberry breeding. The cultivar ‘Elsanta’, developed through the Wageningen breeding program, continues to be widely cultivated throughout Northern Europe, while ‘Sonata’ has gradually replaced part of its production area. The reorganized Fresh Forward breeding initiative has released cultivars such as ‘Vivaldi’, ‘Musica’, and ‘Jive’. Additional private companies have contributed cultivars including ‘Elianny’, ‘Felicita’, ‘Florin Florentina’, ‘Favori’, ‘Pink Extra’, ‘Sussette’, and ‘Fleurette’.

Breeding programs in Poland, Finland, and Norway are mainly focused on adaptation to northern climatic conditions. Poland recently introduced ‘Grandarosa’, while Finnish researchers developed the cultivars ‘Suveatar’, ‘Valotar’, and ‘Lumotar’, emphasizing winter hardiness and disease resistance. In Norway, the privatized Graminor Breeding program released ‘Gudleif’ and ‘Blink’, both characterized by resistance to powdery mildew and suitability for industrial processing (Masny et al., 2015; Hietaranta and Karhu, 2014; Alsheikh and Sween, 2012).

Italy hosts several internationally recognized breeding organizations. The Consorzio Italiano Vivaisti (CIV) developed the popular cultivars ‘Marmolada’ and ‘Clery’ and later introduced numerous day-neutral and June-bearing cultivars, including ‘Murano’, ‘Capri’, ‘Joly’, ‘Nabila’, and ‘Rania’. Other Italian programs have generated cultivars such as ‘Alba’, ‘Roxana’, ‘Alina’, ‘Thelma’, ‘Louise’, ‘Romina’, ‘Cristina’, ‘Pircinque’, ‘Jonica’, ‘Garda’, and ‘Brilla’, many of which are adapted to specific production regions (Baruzzi et al., 2009; Faedi et al., 2014).

China has significantly increased its investment in strawberry breeding during the past two decades. Research institutions in Zhejiang, Hebei, Shanxi, Jiangsu, Shijiazhuang, Shenyang, and Sichuan provinces have developed cultivars and breeding lines adapted to protected cultivation systems and diverse climatic conditions (Yang et al., 2014). Recent releases include ‘Yuezhu’, ‘Yueli’, ‘Baotong’, ‘Ningyu’, and ‘Shimei-7’, while additional programs are exploring ornamental strawberries and the use of wild species to improve fruit aroma (Wang et al., 2012).

Japan and the Republic of Korea maintain advanced breeding programs targeting both protected and open-field cultivation systems. Japanese researchers have developed cultivars for different climatic zones, including interspecific hybrids such as ‘Karume’ and the more recent ‘Tokun’. In Korea, cultivars including ‘Jukhyang’, ‘Maehyang’, ‘Josaenghongsim’, ‘Suhong’, ‘Mihong’, and ‘Geumhyang’ have been developed to combine high fruit quality, low dormancy, and high productivity under forcing culture conditions (Takahashi et al., 2009; Morishita, 2012; Sindarov, 2025).

North America continues to support several collaborative breeding programs. The USDA-ARS program in Beltsville and Corvallis has produced disease-resistant cultivars such as ‘Valley Red’, ‘Charm’, and ‘Sweet Bliss’. Additional breeding efforts at Washington State University and North Carolina State University resulted in cultivars such as ‘Puget Crimson’ and ‘Galletta’. Canadian breeding programs, often conducted in partnership with American institutions, have introduced cultivars including ‘Nisgaa’, ‘Stolo’, ‘Valley Sunset’, ‘ACC Lila’, and the ornamental day-neutral cultivar ‘Roseberry’, highlighting the strong international cooperation that characterizes modern strawberry improvement (Kempler et al., 2011.

Materials and Methods. The research was carried out at the experimental field and biotechnology facilities of the Scientific Research Institute of Vegetable, Melon Crops and Potato Growing, located in the Tashkent district of the Tashkent region, Uzbekistan. The experimental site is characterized by long-term irrigated light sierozem soil with a heavy loam texture. The soil contains approximately 1.1% humus and is relatively poor in essential nutrients; therefore, the application of nitrogen, phosphorus, and organic fertilizers is required to ensure optimal plant growth and high productivity.

The study was designed to evaluate the biotechnological potential of the locally adapted strawberry cultivar 'Tong ifori' and the K-83 and M-11 accessions under controlled greenhouse conditions. Particular attention was given to their in vitro propagation ability, growth and developmental characteristics, regeneration capacity, and productivity-related traits. Throughout the experimental period, morphological, physiological, and propagation parameters were systematically assessed to determine the adaptability and multiplication efficiency of the studied genotypes under protected cultivation conditions.

Results and Discussion.

Nutrient medium is the main factor for the successful cultivation of plant organs, tissues, and cells. The main components of the nutrient medium include mineral salts (macro- and microelements), a carbohydrate source for nutrition (sugar), vitamins, and growth regulators (phytohormones). In some cases, organic additives are also included in the medium, such as coconut milk, yeast extract, and corn endosperm.

Depending on the purpose of the study, the nutrient medium can be either solid (gelled) or liquid. Agar is used for preparing solid media. Iron is also included in the nutrient medium, ensuring its availability to plants.

Most tissues grown in vitro are capable of synthesizing all essential vitamins required for growth. However, at the initial stage—before transferring plant explants into artificial nutrient media—all vitamins must be added externally.

From the perspective of carbohydrate nutrition, plant tissues should be grown on a medium containing sugar. For most tissues, the most suitable carbohydrate source is sucrose at a concentration of 2–5%.

The average pH of the nutrient medium affects the stability and bioavailability of its components. For most plants, the optimal pH ranges from 5.0 to 7.0. Before autoclaving, the pH of the medium is adjusted to 6.5–7.0, since it tends to decrease slightly during autoclaving due to the formation of acidic compounds from sugars (Fig 1).

To speed up the preparation of nutrient media, it is recommended to prepare concentrated stock solutions of macro- and micro-salts, vitamins, and growth regulators in advance.

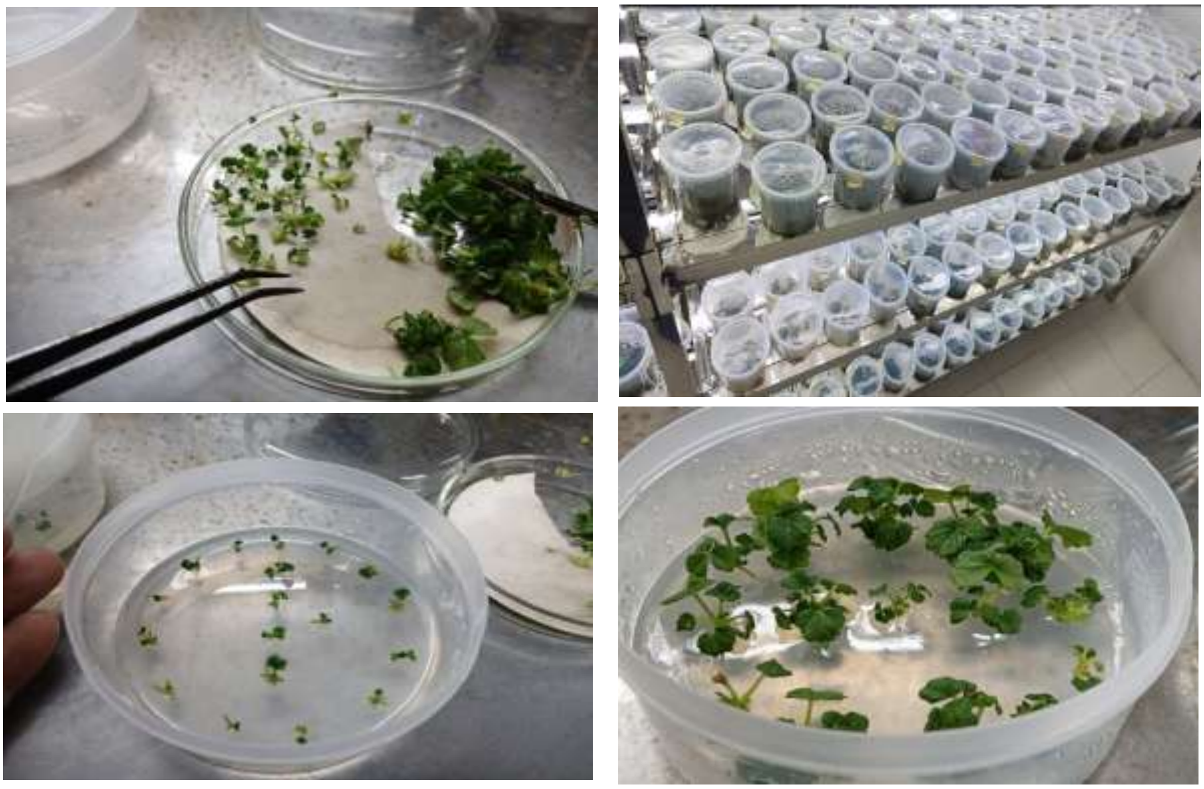

Figure 1. Preparation of in vitro strawberry plantlets for transplantation into the greenhouse.

For preparing these solutions, each salt is weighed separately and dissolved in a fresh portion of distilled water. The solutions are stored in dark glass containers in a refrigerator at 2–4°C for no longer than 4–6 weeks. Vitamin and phytohormone solutions are prepared at a concentration of 1 mg/mL, dissolved in distilled water, and stored in a refrigerator.

Figure 2. Transplantation process of in vitro strawberry plantlets into the greenhouse

In addition, carbohydrates and organic additives are weighed and added directly to the nutrient medium. After all components are added, the solution is brought to the required final volume with water, and the pH of the solution is measured.

In the biotechnology laboratory, strawberry plants grown under sterile conditions in vitro were transferred to a specialized greenhouse. The greenhouse was constructed using modern technology by South Korean specialists and is equipped with systems that allow control of key environmental parameters required for in vitro-derived plantlets, including air temperature and relative humidity (Fig 2).

After transplanting the in vitro strawberry plantlets into the greenhouse, they were irrigated for the first 2 days with plain water, followed by irrigation with a nutrient solution containing macro- and microelements. The greenhouse environment was continuously monitored and controlled.

The establishment (survival and adaptation) of the in vitro strawberry plantlets in the greenhouse was monitored through phenological observations.

When the laboratory-grown in vitro strawberry plantlets were cultivated in different substrates under greenhouse conditions, their survival and establishment rates were as follows.

The in vitro plantlets of the strawberry cultivar "Tong ifori" exhibited significant differences in survival rate and vegetative growth parameters when grown under different substrate conditions.

Table 1. Phenological observation results on the survival (establishment) of in vitro strawberry plantlets in the greenhouse.

№	Substrate names	Plant establishment (survival rate, %)	Number of leaves (pcs)	Leaf area (cm^2)
Tong Ifori navi				
1	**Coco peat**	96,7	7,7	121,0
2	**Perlite**	63,5	3,8	60,5
3	Vermikulet + coco peat (1:1)	87,1	6,0	83,0
4	Perlite + coco peat	73,3	5,5	64,7

Among the tested substrates, coconut peat (coco peat) demonstrated the most favorable results. In this treatment, the survival rate of the plantlets reached 96.7%. In addition, the average number of leaves per plant was 7.7, while the leaf area reached 121.0 cm^2. These results can be attributed to the superior physical properties of coconut peat, particularly its high water-holding capacity, adequate aeration, and its ability to support rapid root adaptation during acclimatization (Tab 1).

In contrast, plants grown in perlite showed considerably lower performance. The survival rate in this substrate was 63.5%, with an average of 3.8 leaves per plant and a leaf area of 60.5 cm². These results indicate the relatively limited moisture retention and lack of inherent nutritional support in perlite, which may restrict early plant development under acclimatization conditions.

In the vermiculite and coconut peat (1:1) mixture, intermediate to high values were recorded. The survival rate reached 87.1%, the average number of leaves was 6.0, and the leaf area was 83.0 cm². This substrate combination provided a more balanced physical and water-holding environment, contributing to improved plant establishment and growth stability.

Similarly, the perlite and coconut peat (1:1) mixture resulted in moderately lower values compared to the vermiculite-based mixture, with a survival rate of 73.3%, an average of 5.5 leaves per plant, and a leaf area of 64.7 cm².

Overall, among all tested treatments, the highest agronomic and morphological performance was recorded in plants grown on coconut peat substrate. Therefore, coconut peat was identified as the most effective medium for the acclimatization and greenhouse establishment of in vitro strawberry plantlets of the cultivar “Tong ifori.”

The root morphological characteristics of the strawberry cultivar “Tong ifori” and the K-83 and M-11 genotypes were evaluated under greenhouse conditions. The results demonstrated considerable variation among the studied materials in terms of root system development.

In the “Tong ifori” cultivar, root length reached 30.0 cm, root spread width was 16.0 cm, and root fresh weight was 4.3 g. These values indicate a well-developed and balanced root system, reflecting stable vegetative growth performance under greenhouse conditions (Tab 2).

Table 2. Morphological characteristics of the root system of strawberry seedlings.

№	Cultivars	Root length (cm)	Root spread width (cm)	Root weight (g)
1	Tong ifori	30,0	16,0	4,3
2	K-83	34,0	15,0	3,7
3	M-11	24,0	11,0	2,4

In the K-83 genotype, the maximum root length was recorded at 34.0 cm, which was higher than in the other studied samples. However, the root spread width and root weight were 15.0 cm and 3.7 g, respectively. This suggests that although K-83 exhibited greater root elongation, its biomass accumulation was slightly lower compared to "Tong ifori."

In contrast, the M-11 genotype showed comparatively lower values for all studied parameters, with a root length of 24.0 cm, root spread width of 11.0 cm, and root weight of 2.4 g. These results indicate a weaker root system development and reduced vegetative vigor under the experimental conditions.

Overall, the findings suggest that root length, root spatial distribution, and root biomass are genotype-dependent traits. These morphological differences play a crucial role in assessing the adaptive capacity and growth potential of strawberry cultivars under greenhouse cultivation systems.

Phenological observations of strawberry mother plantings were conducted from the day of transplanting into the greenhouse. The monitoring included the number of planted seedlings, planting date, and the duration from planting to runner (stolon) formation.

For the "Tong ifori" cultivar, 7.4 thousand seedlings were transplanted on 24 April 2025. Runner formation was recorded after 55 days from planting, indicating relatively early vegetative propagation and faster establishment under greenhouse conditions.

In the K-83 genotype, 2.5 thousand seedlings were planted on the same date (24

April 2025). The onset of runner formation occurred after 62 days, demonstrating a moderately delayed phenological response compared to "Tong ifori."

In the M-11 genotype, 2.6 thousand seedlings were established under identical planting conditions. However, runner formation was observed only after 71 days, indicating a slower developmental rate and delayed vegetative propagation phase.

Overall, the results demonstrate clear genotypic differences in phenological development under greenhouse conditions. The variation in the duration to runner formation suggests that this trait is strongly genotype-dependent and may serve as an important indicator for evaluating propagation efficiency and adaptation potential in strawberry production systems.

Intensive cultivation of strawberry, particularly the production of healthy planting material, largely depends on the effective establishment and management of mother nurseries. In this report, experimental approaches, applied methods, and obtained results related to the propagation of strawberry plantlets in a mother nursery system are presented.

Figure 3. Strawberry plantlets of the "Tong ifori" cultivar.

The study aimed to produce healthy and high-quality strawberry planting material through the establishment of a mother nursery, to evaluate vegetative propagation via runner formation, and to determine optimal agronomic practices under local environmental conditions.

Within the framework of the experiment, several key tasks were implemented, including the establishment of a mother nursery for the multiplication of healthy strawberry seedlings, the assessment of vegetative propagation efficiency through stolon (runner) development, and the identification of optimal agronomic measures suitable for the specific agro-climatic conditions of the region (Fig 3).

The results of these investigations provide a scientific basis for improving the efficiency of strawberry propagation systems and enhancing the quality of planting material under intensive production technologies.

The economic analysis of the production system showed that the total revenue amounted to 88,000,000 UZS, while the total production costs were 47,000,000 UZS. Accordingly, the net profit reached 41,000,000 UZS.

The profitability level of the project was calculated at approximately 72%, indicating a high economic efficiency of the implemented cultivation technology. These results demonstrate that the proposed production system is economically viable and can be considered a cost-effective approach for strawberry cultivation under the given conditions.

Scientific Conclusion

1. Mother plant materials were sterilized using different concentration regimes. The results indicated that the “Tong ifori” cultivar demonstrated higher regeneration capacity and multiplication efficiency, showing strong adaptability and rooting ability under in vitro conditions. Among the evaluated sterilization treatments, the ethanol + NaOCl combination was identified as the most effective, ensuring the highest viability rate (90%) and the lowest contamination level (5%). In contrast, $HgCl_2$ treatment resulted in significantly lower plant viability (60%). Overall, the ethanol + NaOCl combination was found to be the most efficient and safe sterilization method for in vitro strawberry propagation.

2. The multiplication coefficient of the “Tong ifori” cultivar was 15.8%, producing 7.4 thousand plantlets. The K-83 genotype exhibited a multiplication coefficient of 10.2%, with 2.5 thousand plantlets obtained, while the M-11 genotype showed a coefficient of 9.5%, yielding 2.6 thousand plantlets. In total, 12.5 thousand in vitro plantlets were produced across all studied genotypes, indicating substantial propagation efficiency under controlled laboratory conditions.

3. In greenhouse acclimatization experiments, significant differences were observed among substrate treatments for the “Tong ifori” cultivar. The highest survival rate (96.7%) was recorded in coconut peat, accompanied by 7.7 leaves per plant and a leaf area of 121.0 cm². Perlite resulted in lower performance, with a survival rate of 63.5%, 3.8 leaves per plant, and a leaf area of 60.5 cm². The vermiculite + coconut peat (1:1) mixture produced intermediate results (87.1% survival, 6.0 leaves, 83.0 cm² leaf area), while perlite + coconut peat (1:1) showed 73.3% survival, 5.5 leaves, and 64.7 cm² leaf area. Among all treatments, coconut peat alone provided the most favorable conditions for plant establishment and growth.

4. Experimental results demonstrated that supplementation with complex micronutrients (boron, zinc, and manganese) positively influenced vegetative propagation. Enhanced photosynthetic activity, improved root development, and accelerated seedling growth were observed. It is recommended not to rely solely on NPK fertilization but to integrate micronutrient application. Foliar feeding was found to be more efficient in improving nutrient uptake. It is suggested that foliar fertilization in mother nurseries should be conducted 2–3 times per year using spraying systems, with prior soil analysis to optimize fertilization strategies.

5. The study confirmed that strawberry seedlings can be successfully propagated vegetatively in mother nurseries under Uzbek conditions. The application of drip irrigation systems and modern agronomic practices significantly improves both the quality and quantity of planting material, ensuring efficient production of healthy seedlings.

6. In hydroponic strawberry cultivation, environmental factors such as temperature, lighting, and nutrient supply play a critical role. Proper management of fertilization and irrigation systems can significantly increase yield performance. Under controlled greenhouse conditions during autumn, winter, and spring seasons, optimal environmental regulation enables stable and high productivity.

References

1. Alsheikh, M. and Sween, R. (2012) Advances in the Norwegian Strawberry Breeding Program. In: VII International Strawberry Symposium, 18–22 February, Beijing, China, Poster 8.

2. Baruzzi, G., Faedi, W., Lucchi, P., Migani, M., Sbrighi, P. and Turci, P. (2009) Performance of Italian strawberry genotypes on fumigated, non-fumigated soils and organic culture. Acta Horticulturae 842, 553–556.

3. Chandler, C., Folta, K., Dale, A., Whitaker, V. and Herrington, M. (2012) Strawberry. In: Badenes, M.L. and Byrne, D.H. (eds) Fruit Breeding. Springer-Verlag, New York, pp. 305–325.

4. Della Strada, G. and Fideghelli, C. (2011) The Fruit Varieties Released in the World from 1980 through 2008. Centro di Ricerca per la Frutticoltura and Ministero delle Politiche Agricole, Alimentari e Forestali, Rome, Italy.

5. Domínguez, P., Medina, J.J., López-Aranda, J.M., Ariza, M.T., Miranda, L., Amaya, I., Sánchez-Sevilla, J.F., Villalba, R. and Soria, C. (2012) 'Santaclara' strawberry. HortScience 47, 948–951.

6. Faedi, W., Baruzzi, G., Lucchi, P., Magnani, S., Maltoni, M.L., Migani, M., Sbrighi, P., Ballini, L., Baroni, G., Cossio, F., Capriolo, G. and Carullo, A. (2014) Updates on Italian strawberry breeding programs coordinated by CRA-FRF. Acta Horticulturae 1049, 877–882.

7. Hietaranta, T.P. and Karhu, S.T. (2014) Enhancing strawberry production at high latitudes. Acta Horticulturae 1049, 73–76.

8. Kempler, C., Daubeny, H.A., Harding, B., Frey, L., Baumann, T.E., Finn, C.E., Khanizadeh, S., Jamieson, A.R., MacKenzie, K., Moore, P.P. and Sweeney, M. (2011) ‘Stolo’ strawberry. HortScience 46, 1046–1048.

9. Masny, A., Z˙ urawicz, E. and Markowski, J. (2015) ‘Grandarosa’ strawberry. HortScience 50, 1401–1404.

10. Roudeillac, P. and Markocic, M. (1997) Improved flavour and soil disease tolerance: two major aims of the breeding programme at CIREF for new advanced selections combining good commercial potential. Acta Horticulturae 439, 139–144.

11. Sindarov O.X. Integration of smart farming technologies for sustainable strawberry production in controlled environments // Journal “Sustainable Agriculture”. – “TIAME” NRU, 2025. –2(26). – P. 43–49.

12. Takahashi, H., Yamasaki, A., Shoji, K., Kawagishi, K., Taguchi, T., Yoshida, Y. and Morishita, M. (2009) Present status and prospects of strawberry breeding and cropping type in northern Japan. Acta Horticulturae 842, 475–478.

13. Wang, J., Zhao, M.Z., Wang, Z.W., Yu, H.M. and Huang, W.Y. (2012) ‘Ningyu’: a Chinese new cultivar with high level reducing sugar, ascorbic acid and antioxidant capacity. Acta Horticulturae 1049, 231–235.

14. Yang, L., Li, L., Yang, L., Zhang, J., Li, H. and Ha, B. (2014) Strawberry cultivar ‘Shimei-7’ for sightseeing and fruit-picking tourism. Acta Horticulturae 1049, 247–248.