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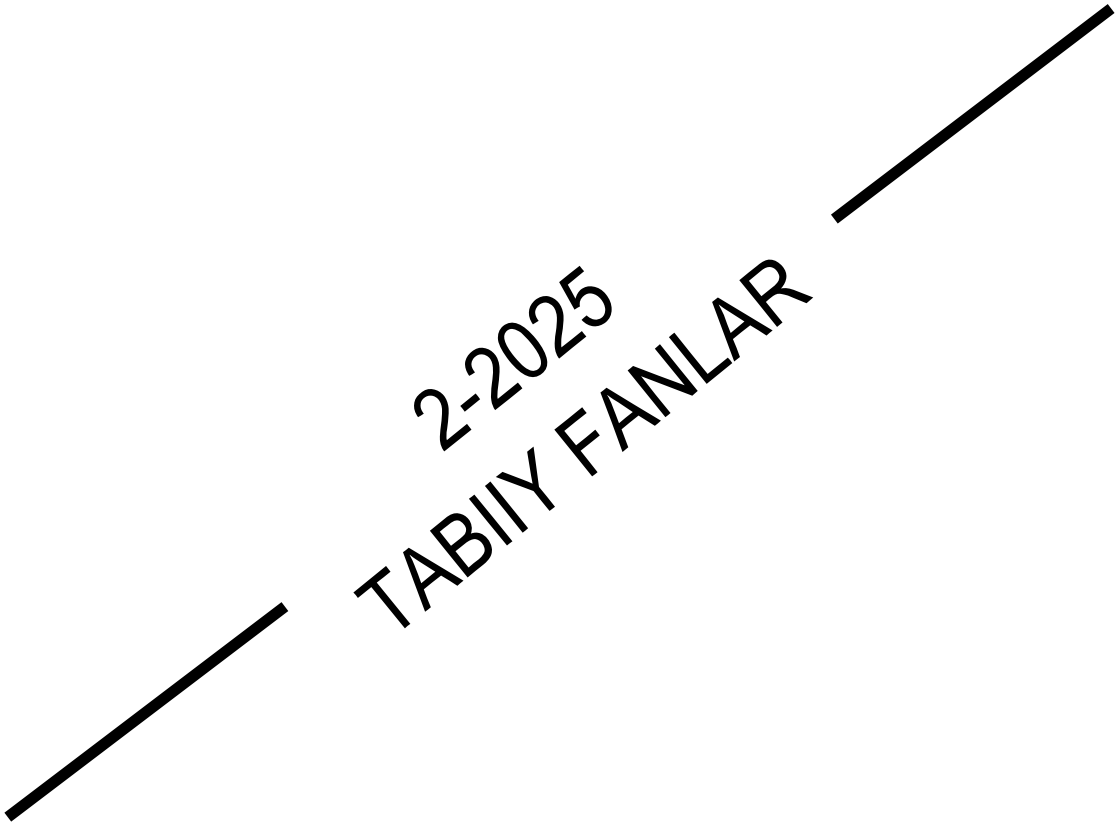

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EVALUATING SUBSTRATE TYPES FOR ENHANCED HYDROPONIC STRAWBERRY YIELD AND QUALITY

ОЦЕНКА ТИПОВ СУБСТРАТА ДЛЯ УЛУЧШЕННОГО УРОЖАЯ И КАЧЕСТВА КЛУБНИКИ В ГИДРОПОНИКЕ

GIDROPONIK USULDA YUQORI HOSIL VA SIFATLI QULUPNAY YETISHTIRISH UCHUN SUBSTRAT TURLARINI BAHOLASH

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Abstract

Strawberries are a widely consumed fruit, valued for their nutritional benefits and sensory qualities, including high levels of bioactive compounds. Traditional soil-based cultivation poses challenges such as limited growing seasons and susceptibility to soil-borne diseases, prompting interest in hydroponic systems for strawberry production. The choice of substrate plays a critical role in hydroponic systems, influencing water retention, aeration, and nutrient availability, which directly impacts plant growth and fruit quality. This study evaluates three substrates coconut coir, perlite, and soil on their effectiveness in enhancing hydroponic strawberry yield and quality. The experiment, conducted in a controlled hydroponic environment, measured growth parameters including stem height, number of leaves, number of flowers, and flowering rate. Results showed that coconut coir outperformed both perlite and soil, with the highest values across all growth parameters. These findings suggest that coconut coir is the most effective substrate for optimizing hydroponic strawberry growth, making it a suitable choice for hydroponic strawberry production systems aiming to maximize yield and fruit quality.

Аннотация

Клубника это широко потребляемый фрукт, ценящийся за свои питательные свойства и сенсорные качества, включая высокие уровни биоактивных соединений. Традиционное грунтовое выращивание сталкивается с такими проблемами, как ограниченные сезоны роста и восприимчивость к почвенным заболеваниям, что приводит к повышенному интересу к гидропонным системам для выращивания клубники. Выбор субстрата играет критическую роль в гидропонных системах, влияя на удержание воды, аэрацию и доступность питательных веществ, что напрямую сказывается на росте растений и качестве плодов. В этом исследовании оцениваются три субстрата: кокосовый субстракт, перлит и почва, их эффективность в улучшении урожайности и качества гидропонной клубники. Эксперимент проводился в контролируемой гидропонной среде, где измерялись параметры роста, включая высоту стебля, количество листьев, количество цветов и скорость цветения. Результаты показали, что кокосовый субстракт превзошел как перлит, так и почву, показав наивысшие значения по всем параметрам роста. Эти результаты свидетельствуют о том, что кокосовый субстракт является наиболее эффективным субстратом для оптимизации роста гидропонной клубники, что делает его подходящим выбором для гидропонных систем выращивания клубники, нацеленных на максимизацию урожайности и качества плодов.

Annotatsiya

Qulupnay keng tarqalgan iste’mol qilinadigan meva bo‘lib, uning foydalari va xususiyatlari, shu jumladan bioaktiv birikmalarning yuqori darajasi bilan qadrlanadi. An’anaviy tuproq asosidagi yetishtirish tizimlari o‘sish mavsumining cheklanganligi va tuproq orqali yuqadigan kasalliklarga moyilligi kabi muammolarni keltirib chiqaradi, shuning uchun gidroponik tizimlarga bo‘lgan qiziqish kuchaymoqda. Substrat tanlovi gidroponik tizimlarda muhim rol o‘ynaydi, chunki u suvni ushlab turish, havolantirish va ozuqa moddalarining mavjudligiga ta’sir qiladi, bu esa o‘simlik o‘sishi va meva

sifatiga to‘g‘ridan-to‘g‘ri ta’sir ko‘rsatadi. Ushbu tadqiqot, kokos tolasining, perlit va tuproqning gidroponik qulupnay hosilini va sifatini oshirishdagi samaradorligini baholaydi. Eksperiment, nazorat ostidagi gidroponik muhitda o‘tkazilib, o‘sish parametrlari o‘lchandi, jumladan, poyaning balandligi, barglar soni, gullar soni va gullash tezligi. Natijalar kokos tolasining perlit va tuproqdan ustunligini va barcha o‘sish parametrlarida eng yuqori qiymatlarni ko‘rsatdi. Ushbu natijalar kokos tolasining gidroponik qulupnay o‘sishini optimallashtirish uchun eng samarali substrat ekanligini, shu bilan birga, hosilni va meva sifatini maksimal darajada oshirishni maqsad qilgan gidroponik qulupnay yetishtirish tizimlari uchun mos kelishini ko‘rsatadi.

Key words: *Hydroponics, substrates, perlite, coconut coir, root, water retention.*
Ключевые слова: *Гидропоника, субстраты, перлит, кокосовый субстракт, корни, удержание воды.*
Kalit so‘zlar: *Gidroponika, substrat, perlit, kokos tolasi, ildiz, suvni ushlab turish.*

INTRODUCTION

Strawberry is a world-wide consumed soft fruit, highly appreciated as a source of bioactive compounds, including vitamins, healthpromoting antioxidants, polyphenolic compounds, flavonoids, anthocyanins, and amino acids, as well for its organoleptic and sensorial quality (Giampieri et al., 2012). It represents a significant economic crop, with various cultivars exhibiting notable differences in taste, aroma, and nutritional value. Consequently, the discrimination and characterization of different strawberry varieties to assess their quality have become pressing issues that require attention (Xu et al., 2024). It is commonly produced as earlyspring crop or out-of-season in open field, glasshouseor polyethylene tunnel. Pests and diseases in soilculture have always been problems especially inprotected areas. Traditional soil-based cultivation poses several challenges, including soil-borne diseases and limited growing seasons. Hydroponics offers a viable alternative, allowing for precise control over environmental conditions and nutrient delivery. The substrate used in hydroponic systems influences water retention, aeration, and nutrient availability, which directly impacts plant growth and fruit quality (Sahin et al., 2004).

Coconut coir is a versatile and sustainable growing medium derived from the fibrous husks of coconuts. This natural substrate is highly regarded in horticulture and hydroponics for its excellent moisture retention and aeration properties. (Shuttleworth et al., 2021) Coir holds water effectively, allowing plants to access moisture without frequent watering, which is especially beneficial in hydroponic systems. Additionally, it provides good air pockets that promote healthy root respiration. Coir is generally pH neutral, making it suitable for a wide range of plants. Its organic nature contributes some nutrients to the growing medium, and it improves soil structure when mixed with other substrates (Woznicki et al., 2024). As a biodegradable material, coconut coir is also an environmentally friendly alternative to peat moss, helping to reduce the ecological impact of gardening practices.

Perlite is a lightweight, volcanic glass that has been heated and expanded to create small, white particles commonly used in gardening and hydroponics. Known for its exceptional drainage capabilities, perlite prevents waterlogging and helps maintain optimal moisture levels in the root zone (Shylla et al., 2018). Its structure promotes aeration, allowing roots to breathe and preventing diseases associated with stagnant water. While perlite itself is inert and contains no nutrients, it enhances the performance of soil mixes by improving aeration and drainage (Stirling, 1997). This makes it particularly useful in hydroponic systems and as a soil amendment for potted plants. Due to its lightweight nature, perlite is easy to handle and transport, making it a favorite among gardeners (Bamforth, 2006).

Traditional soil is a complex mixture of minerals, organic matter, air, and water, forming the foundational growing medium for most plants. Soil provides a rich nutrient base that supports healthy plant growth and development. Its composition varies widely, affecting moisture retention, drainage, and nutrient availability (Milosevic et al., 2009). Soil’s ability to retain moisture is influenced by its texture and organic matter content; sandy soils drain quickly, while clay soils retain moisture longer. Soil also supports a diverse ecosystem of microorganisms that contribute to nutrient cycling and plant health. Though soil is renewable, its fertility can be depleted over time without proper management, such as crop rotation and organic amendments (Cao et al., 2023).

This research aims to assess the performance of different substrates in enhancing hydroponic strawberry yield and quality. The choice of substrate is crucial, with options like perlite and coconut coir providing excellent aeration and water retention.

MATERIALS AND METHODS

The substrates evaluated in this study were:

1. **Coconut Coir**: A natural fiber known for its moisture retention and aeration properties.
2. **Perlite**: A lightweight volcanic glass that provides excellent drainage and aeration.
3. **Soil**: Traditional soil rich in organic matter and nutrients.

The experiment was conducted in a controlled hydroponic environment with 45 strawberry plants (15 per substrate type). Each plant was grown under identical conditions, with regular monitoring of temperature (20-25°C) and humidity (60-70%). Nutrient solutions were provided according to standard recommendations for strawberries.

Growth parameters measured:

- Average Stem Height
- Number of Leaves
- Number of Flowers
- Flowering Rate

Data were collected from plants grown in each substrate over a specified period. The results were analyzed to compute percentage differences among the substrates.

Table 1

Comparison of Substrate Features for Plant Growth: Coconut Coir, Perlite, and Soil

Feature	Coconut Coir	Perlite	Soil
Moisture Retention	High	Low	Variable (depends on type)
Aeration	Good	Excellent	Variable (depends on composition)
Nutrient Content	Contains some nutrients	Inert (no nutrients)	Rich in nutrients
pH Level	Neutral (6-7)	Neutral (around 7)	Variable (6-8)
Sustainability	Biodegradable and renewable	Non-renewable, but reusable	Renewable if managed properly
Weight	Heavier than perlite	Very lightweight	Heavier, depending on moisture
Use Cases	Hydroponics, potting mixes	Soil amendment, hydroponic mixes	General gardening, landscaping

RESULTS

The primary parameters measured included average stem height, number of leaves, number of flowers, and flowering rate. The results clearly indicated significant differences in the growth and flowering performance of the strawberry plants based on the substrate used.

Table 2

Summarizes the effects of each substrate on strawberry growth

Substrate	Average Stem Height	Number of Leaves	Number of Flowers	Flowering Rate
Coconut Coir	Highest (30 cm)	Highest (12 leaves)	Highest (15 flowers)	Highest (90%)
Perlite	Medium (28 cm)	Medium (10 leaves)	Medium (12 flowers)	Medium (60%)
Soil	Lowest (25 cm)	Lowest (8 leaves)	Lowest (10 flowers)	Medium (70%)

Table 2 provides a summary of the effects of each substrate on strawberry plant growth. Strawberry plants grown in coconut coir exhibited the highest average stem height of 30 cm, significantly outperforming both perlite and soil. This suggests that coconut coir promotes greater vertical growth compared to the other substrates. Additionally, plants grown in coconut coir also produced the highest number of leaves, with an average of 12 leaves per plant, followed by perlite

and soil. The superior performance in leaf production observed in coconut coir suggests it provides better conditions for vegetative growth. In terms of flower production, the coconut coir group again showed the highest number of flowers, with an average of 15 flowers per plant, compared to 12 flowers in perlite and 10 flowers in soil. This indicates that coconut coir is particularly effective in promoting flowering. Moreover, the flowering rate was highest in the coconut coir group, with 90% of plants reaching the flowering stage. In contrast, perlite exhibited the lowest flowering rate at 60%, while soil plants had a medium flowering rate of 70%. This suggests that coconut coir supports a higher percentage of plants reaching full bloom compared to the other substrates.

Table 3

Presents the percentage differences among the substrates based on growth parameters

Growth Parameter	Comparison	Percentage Difference (%)	Performance
Average Stem Height	Coir vs. Perlite	7.14%	Higher (Coir)
	Coir vs. Soil	20.00%	Higher (Coir)
	Perlite vs. Soil	12.00%	Higher (Perlite)
Number of Leaves	Coir vs. Perlite	20.00%	Higher (Coir)
	Coir vs. Soil	50.00%	Higher (Coir)
	Perlite vs. Soil	25.00%	Higher (Perlite)
Number of Flowers	Coir vs. Perlite	25.00%	Higher (Coir)
	Coir vs. Soil	50.00%	Higher (Coir)
	Perlite vs. Soil	20.00%	Higher (Perlite)
Flowering Rate	Coir vs. Perlite	50.00%	Higher (Coir)
	Coir vs. Soil	28.57%	Higher (Coir)
	Perlite vs. Soil	-14.29%	Lower (Perlite)

Impact of substrates on strawberry growth

1. coconut coir, 2. perlite, and 3. soil

The percentage differences between the substrates based on the growth parameters are presented in Table 3. Coconut coir plants had a 7.14% higher average stem height than those grown in perlite and a 20.00% higher height compared to those grown in soil, clearly demonstrating its superiority in vertical growth. In terms of leaf production, coconut coir produced 20.00% more leaves than perlite and 50.00% more than soil, with perlite plants having 25.00% more leaves than those grown in soil. This indicates that both coconut coir and perlite are more effective than soil in promoting leaf growth. For flower production, the number of flowers was 25.00% higher in coconut coir compared to perlite and 50.00% higher compared to soil, with perlite showing a 20.00% increase in flower number over soil. In terms of flowering rate, coconut coir plants exhibited a 50.00% higher flowering rate compared to perlite and a 28.57% higher rate compared to soil. Conversely, perlite plants showed a 14.29% lower flowering rate compared to soil, suggesting that perlite may not be as conducive to flowering as either coconut coir or soil.

DISCUSSION

The analysis reveals that Coconut Coir is the most effective substrate for promoting plant growth. It consistently produced higher values across all measured parameters. The superior moisture retention and aeration properties of Coconut Coir likely contributed to enhanced root development and nutrient uptake. In contrast, Perlite showed moderate performance, particularly in flowering rate, where it performed worse than both Coconut Coir and Soil. This indicates that while Perlite may facilitate good drainage, it may not provide adequate nutrient retention for flowering

plants. Soil, while commonly used, demonstrated the least effectiveness in promoting growth parameters, particularly in stem height and number of leaves. This suggests that traditional soil may not be ideal for optimizing plant growth compared to more modern substrates like Coconut Coir.

CONCLUSION

The results of this study clearly indicate that coconut coir is the most effective substrate for promoting strawberry growth and flowering in hydroponic systems. It outperformed both perlite and soil in all measured parameters, including stem height, leaf production, flower number, and flowering rate. Perlite, while improving aeration and drainage, showed intermediate results and was less effective than coconut coir in supporting overall plant growth and flowering. On the other hand, soil, despite its nutrient content, resulted in the poorest performance, particularly in terms of growth and flowering. These findings suggest that coconut coir is the most suitable substrate for enhancing the yield and quality of hydroponic strawberries.

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