Optimization of Germination and Seedling Development in (*Juglans regia* L.) Cultivars Using Different Growing Media

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Abstract

This study aimed to evaluate the effects of three different growing media loamy soi(G1), silty (G2) clay , and a peat moss-perlite mix (G3) on the germination and growth of three walnut cultivars (*Juglans regia* L.): Denarta (C1), Choman (C2), and Hawraman (C3). Results showed that both growing media and cultivar type significantly influenced germination rates and seedling growth parameters. The highest germination percentage was observed in G3 for C3 (81.48% and 92.59%) respectively. Furthermore, the combination of G3 and C3 produced the greatest seedling height (25.33 cm) and root length (18.33 cm). These findings suggest that peat moss-perlite (G3) is the most suitable growing medium for walnut seedling propagation, and the Hawraman cultivar (C3) exhibits the best growth performance. This combination is recommended for walnut nursery operations and reforestation efforts in the Kurdistan region.

Keywords: *Juglans regia*, growing media, seedling growth, walnut cultivars, and germination

Introduction

The genus Juglans belongs to the Juglandaceae family consisting of seven genera and including 20 species, characterized by monoecious trees and all producing edible nuts. Among those, *Juglans regia* L. the English or Persian walnut is the most economically important species. Its cultivars are grown primarily for nut production, timber and as ornamental trees [1]. *Juglans regia* L. is a large deciduous tree with a trunk up to 2 m in diameter and expansive crown that may reach heights of 20-35 m. It is native to Central Asia, Eastern Europe, and North America [2]. They are successfully cultivated in Iran, the United States, North India, and Central America, and grow at elevations of 1200-2000 meters above sea level [3]. The normal growth and maturation of walnut trees required the fertile soils and temperate climate with annual rainfall 700mm and temperature ranged between 25- 35 ºC [4].

Anders, [5] find out that Walnut grows abundantly in the Kurdish highlands; it has been recorded from Rowanduz Gorge, Ryatt Valley, Shaqlawa, Zwaratuka Amadiya, and other locations. The seeds of this species have deep physiological

dormancy that is controlled by seed coat and embryo dormancy. To achieve a proper seed germination and homogenous seedling growth, seed dormancy must be removed [6].

Comparing plants grown in containers to those cultivated in the field, the former have much less access to growing media. For example, seedlings of forest trees are grown in pots that range in volume from 40 to 700 cm^3. Because of their limited ability to root, seedlings have less readily available sources of nutrients and water, and these essential resources might fluctuate quickly [7]. Selecting the best growing media for potted development is crucial to achieving a successful plant production, which improves the growth of healthy seedlings and streamlines and expedites processes. These seedlings will be more resilient to environmental stressors as well [8]. Soil mixtures like soil/sand are preferred instead of single materials for the germination process, because they usually have better physical and chemical characteristics that increase germination percentage in comparison to single materials [9]. Furthermore, growing media can include organic materials such as peat, compost, tree bark, coconut (*Cocos nucifera* L.) coir, poultry feathers, or inorganic materials such as clay, perlite, vermiculite, and mineral wool [10].

Loamy soil is a soil composed mostly of sand, silt and a smaller amount of clay. By weight, its mineral composition is about 40–40–20% concentration of sand–silt–clay, respectively. Peat moss harvested from peat bogs, it is the least degraded of the peat varieties, with a pH ranging from 3.8 to 4.3. It is generally tan to brown in color, lightweight, and has a good moisture-holding capacity [11]. Furthermore, Perlite is a very lightweight soil amendment is used throughout the world as a component of soil-less growing mixes where it provides aeration and optimum moisture retention for superior plant growth. Expanded perlite has several attractive physical properties for commercial applications including low bulk density, low thermal conductivity, high heat resistance, low sound transmission, high surface area, and chemical inertness. The physical properties of container-growing substrates, particularly air space, container capacity, and bulk density, have a significant impact on plant growth, and knowledge of these properties is essential in properly managing nursery irrigation and fertilization programs [12]. The aim of the study is to investigating the effect of growing media on germination and seedling growth characters for three types of cultivars of *Juglan regia* L. seedling, and find out the differences between the cultivars in term of germination and seedling growth.

Materials and Methods

Experimental Design and Analysis

The experiment was conducted from October 2023 to March 2024 in the plastic house of the College of Agricultural Engineering Sciences at Salahaddin University-Erbil. Three types of growing media were used in the study. The first growing medium (G1) was loamy soil, a well-balanced soil type composed of sand, silt, and clay. The second growing medium (G2) consisted of silty clay, which is heavier and

retains more moisture compared to loamy soil. The third growing medium (G3) was a mixture of peat moss and perlite in a 32:20 ratio. This combination is known for its excellent moisture retention, aeration, and drainage properties, making it highly suitable for seedling growth. In addition to the growing media, three walnut cultivars were tested. The first cultivar (C1), Denarta, was sourced from Denarta town in the Duhok Governorate. The second cultivar (C2), Choman, originated from Wezy village in Choman, located in Erbil Governorate. The third cultivar (C3), Hawraman, was obtained from Zalam village in Khurmal, Halabja Province. These cultivars were selected based on their regional adaptations and potential for high growth performance.

Pre-treatment of Seeds

Before sowing, the seeds were subjected to two pre-treatments to enhance germination. First, the seeds were manually cracked to break the seed coat and facilitate germination. Following this mechanical treatment, the cracked seeds were soaked in water for 48 hours to further soften the seed coat and accelerate the germination process. The average seed weights for the cultivars were 11.7 g for Denarta (C1), 11.21 g for Choman (C2), and 13.99 g for Hawraman (C3).

Sowing Procedure

On October 26, 2023, seeds were sown in 13 cm plastic pots, each filled with one of the respective growing media. Each pot contained a single seed, and the experiment was set up in a factorial, completely randomized design (CRD) with nine treatments, representing the combination of three growing media and three walnut cultivars, replicated three times. Each replicate consisted of three pots, resulting in a total of 81 experimental units. After sowing, the pots were watered regularly to ensure consistent moisture across all treatments. Environmental conditions, such as temperature and humidity, were carefully monitored within the plastic house to maintain optimal growth conditions for the walnut seedlings.

Data Measurements

Data measurement was conducted at two time points:

1. **Eight weeks after planting (December 2023)**: Germination percentage was recorded.
    - Germination percentage (GP) was calculated using the formula:

    $GP = \sum G/N*100$ [13,14].

    Where GP is the germination percentage, G is the number of germinated seeds and N is the total number of seeds sown.
2. **Final data collection (March 3, 2024)**: Growth parameters were measured, including:
    - Seedling height (cm): Measured from the base to the terminal bud.
    - Seedling diameter (mm): Measured at the soil surface using a digital micrometer.
    - Root length (cm): Measured after carefully washing the roots free of soil.

- Number of leaves per seedling.

Statistical Analysis

Data were analyzed using analysis of variance (ANOVA) to determine the significance of the effects of growing media, walnut cultivar, and their interactions on germination and seedling growth parameters. The Minitab software was used for statistical analysis. The differences between treatments means were subsequently assessed using the Duncan test at level of significance $p \leq 0.05$.

Results and Discussion

Germination Percentage

The germination rate of *Juglans regia* L. cultivars during the different growing media is presented in Table 1. Out of the three media applied, peat moss + perlite (G3) showed the best germination ability with a mean value of 81.47%, followed by salty clay soil (G2) with 62.95% and loamy soil (G1) with 48.14%. This implies that the growing medium has an important influence on seed germination, with G3 being perhaps more favorable as it probably has a better aeration and capacity of humidity.

Among the cultivars, Choman (C2) and Hawraman (C3) were found to be significantly superior in terms of germination percentages over all media, both with a high mean values of 66.65% and 92.58%, respectively while lowest germination rates was recorded for Denarta (C1). This implies great genetic diversity within the cultivars for growing environment adaptability. Exclusively, the interaction between the Hawraman cultivar and peat + perlite.

Table (1): Germination percentage of *Juglans regia* L. cultivars at different growing media

Growing media	Walnut (*Juglans regia*) cultivars			
	(Denarta)	(Choman)	(Hawraman)	Mean of growing media
(Loamy Soil)	11.11	14.81	22.22	48.14
(Salty Clay)	11.11	22.22	29.62	62.95
(Peat moss + Perlite)	11.11	29.62	40.74	81.47
Mean of cultivars	33.33	66.65	92.58	

Growth Parameters

Table 2, shows the effects of different growing media and walnut cultivars on the growth characteristics. For the growing media, G3 (peat moss + perlite) stands out as the most effective in promoting growth, producing the highest seedling diameter (5.591 mm) and seedling height (23.78 cm). In comparison, G1 (loamy soil) and G2 (silty clay) resulted in smaller seedling diameters (4.683 mm and 4.711 mm, respectively) and shorter seedling heights. However, the number of leaves was not significantly different across the growing media.

Among the walnut cultivars, C3 (Hawraman) showed the greatest seedling height (24.17 cm), indicating that this cultivar performs best in terms of height growth. The differences in seedling diameter across the cultivars were minimal, with C1, C2, and C3 showing similar results (around 5 mm). Additionally, the number of leaves was also relatively consistent across the cultivars. Overall, G3 growing medium and the C3 cultivar produced the most robust seedlings.

Table (2): Effects of walnut cultivars and growing media on number of leaves, seedling diameter and Seedling height of *Juglans regia* L.

Factors	Leaves Number	Seedling Diameter (mm)	Seedling height (cm)
G1	10.77 a	4.683 b	19.29 ab
G2	10.888 a	4.711 b	18.17 b
G3	13.555 a	5.591 a	23.78 a
C1	11.111 a	4.980 a	17.46 b
C2	12.444 a	5.005 a	19.61 b
C3	11.666 a	5.000 a	24.17 a

Interaction effects

Table 3, presents the interaction effects between different growing media and walnut (*Juglans regia* L.) cultivars on the number of leaves, seedling diameter, and seedling height. The results demonstrate significant variation in seedling growth characteristics depending on the combination of growing media and cultivar. In terms of leaves number, no statistically significant differences were observed between the treatments. For seedling diameter, the G3C2 treatment (Peatmoss + Perlite with Choman) recorded the highest value of 6.233 mm, significantly larger than several other combinations, such as G1C2 (Field Soil with Choman), which exhibited the smallest diameter (4.100 mm). This suggests that the Peatmoss + Perlite growing medium had a more pronounced effect on increasing seedling diameter compared to the other media. Regarding seedling height, the G3C3 treatment (Peatmoss + Perlite with Hawraman) resulted in the greatest seedling height (25.33 cm), followed closely by G1C3 (Field Soil with Hawraman) at 24.67 cm. In contrast, the lowest seedling height was recorded for the G1C1 treatment (Field Soil with Denarta) at 13.87 cm. These findings indicate that the Peatmoss + Perlite medium, particularly when combined with the Hawraman cultivar, was the most effective for enhancing seedling height.

Overall, the interaction of Peatmoss + Perlite as the growing medium and the Hawraman cultivar consistently promoted superior seedling growth across all measured parameters, particularly in seedling diameter and height. In contrast, the field soil medium resulted in comparatively lower seedling growth, suggesting that it may not be as conducive to seedling development as Peatmoss + Perlite.

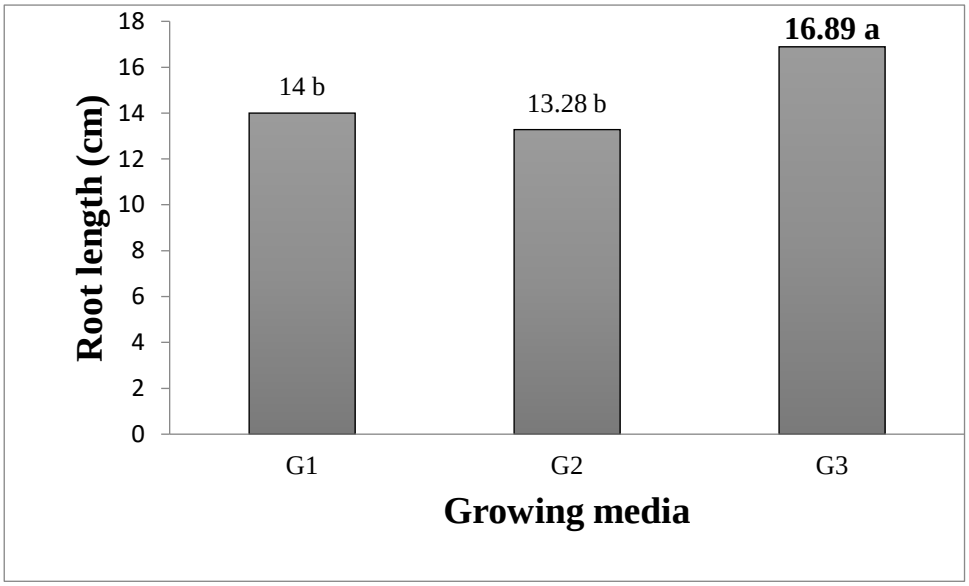
Table (3): The interaction effect of walnut cultivars and growing media on the number of leaf, seedling diameter, and seedling height of *Juglans regia* L.

Growing Media × Cultivar	Leaf Number	Seedling Diameter (mm)	Seedling Height (cm)
G1C1	14.00 a	5.233 ab	13.87 c
G1C2	8.666 a	4.100 b	19.33 abc
G1C3	9.666 a	4.716 b	24.67 a
G2C1	8.666 a	4.500 b	16.33 bc
G2C2	13.33 a	4.666 b	15.67 bc
G2C3	10.66 a	4.966 ab	22.50 ab
G3C1	12.33 a	5.206 ab	22.17 ab
G3C2	15.33 a	6.233 a	23.83 ab
G3C3	13.00 a	5.333 ab	25.33 a

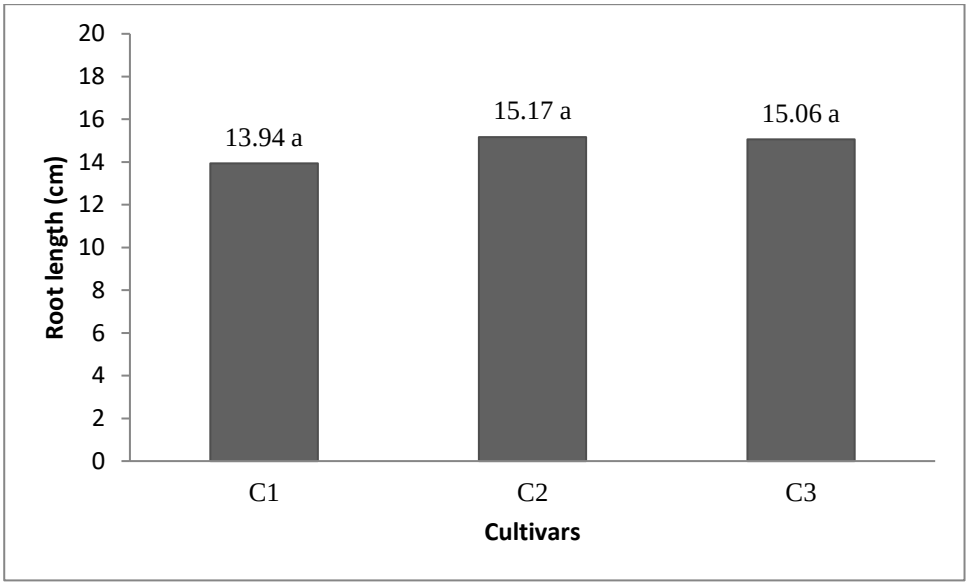
Means with the same letter in a column for each factor are not significantly different by Duncan's multiple range test at $p \leq 0.05$.{(G1=field soil, G2= loamy soil, G3= peatmoss+perlite) (C1= denarta culitver, C2=choman cultivar, C3=hawraman cultivar)}.

Effects on root length

Figures (4) and (5) reveal the influence of growth media and walnut cultivars on the root length of *Juglans regia* L. seedlings, where the largest mean value was found in seedlings grown in third growing media and second type of walnut cultivars, measuring 16.82 cm and 15.17 cm respectively. Conversely, the first cultivar and second growing media produced the lowest mean values (13.28 cm) and (13.94 cm) respectively.



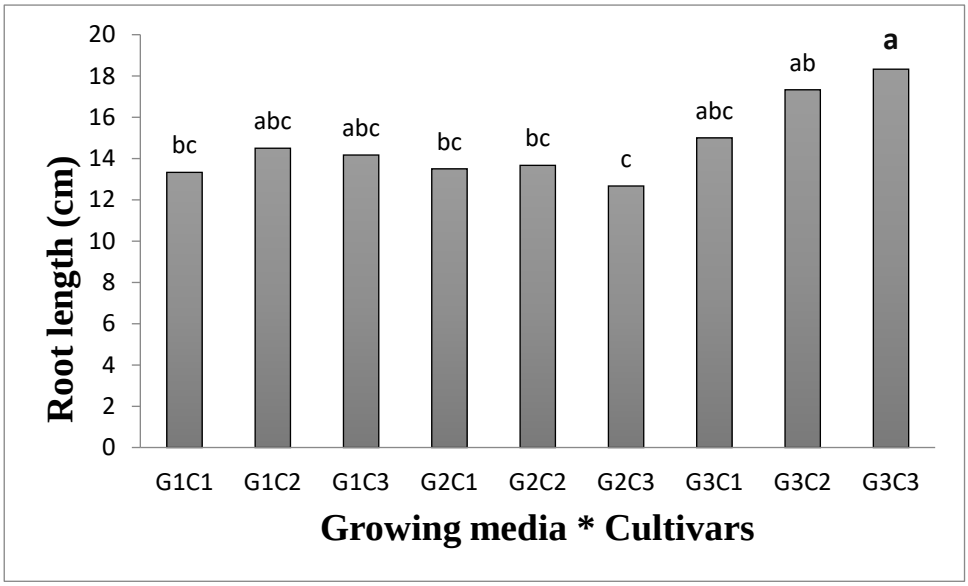
Figures (4): Effect of growing media on root length of *Juglans regia* L.



Figures (5): Effect of walnut cultivars on root length of *Juglans regia* L.

Interaction effects

The combined effect of growing media and walnut cultivars on the root length of *Juglans regia* L. is shown in Figures (6) Where maximum mean value of the root length was recorded in third growing media and third type of cultivar (18.33cm) and the minimum mean value was gained in second growing media and third type of cultivar (12.67cm).



Figures (6): Interaction effect of growing media and walnut cultivars on root length of *Juglans regia* L.

At end of the study the results indicated that after five months of planting the germination percentage for growing media and walnut cultivars had the largest value in G3 and C3 (81.48% and 92.59%) respectively. Additionally the combination of growing media and walnut cultivars on mean of leaves number and mean of seedling diameter had a significant effect on seedling diameter only, where the maximum mean value of this growth character was achieved from the seedlings grown in third growing media and second type of walnut cultivar (6.233), furthermore the interaction effect of growing media and walnut cultivars on the seedling height and root length recorded in third growing media and third type of cultivar G3C3 (25.33 cm, 18.33cm respectively). All the results mentioned above demonstrates that the third growing media (G3) which is the combination of peat moss and perlite gave greatest mean value for all studied characters (Germination present, Seedling diameter, Seedling height, Root length) and is often regarded as an optimal growing medium for walnut trees this is due to Perlite, being a lightweight, porous material, promotes excellent aeration within the soil mixture, this is crucial for root health as it ensures proper oxygen levels, preventing root suffocation and promoting healthy root development also both peat moss and perlite contribute to good drainage, preventing waterlogging which can lead to root rot and other moisture-related issues [15], and this is important for walnut trees, which prefer well-draining soil .In addition peat moss and perlite provide a loose, friable texture which facilitates root penetration and growth, this allows the walnut tree's roots to spread out and establish themselves more effectively [16].

Additionally peat moss has excellent moisture-retention properties, helping to ensure that the soil remains consistently moist but not waterlogged. This is important for maintaining optimal growing conditions for the walnut tree's roots. Moreover

Peat moss can also hold onto nutrients, making them available to the tree's roots over time [9]. This can help provide a steady supply of essential nutrients for healthy growth. Furthermore Peat moss tends to be slightly acidic, which is favourable for many plants including walnuts. It creates an environment where essential nutrients are more readily available to the plant roots [14].

Furthermore the results mentioned above illustrated that the third walnut cultivar (C3) Hawraman cultivar gave greatest mean value for most studied characters (Germination present, Seedling diameter, Seedling height, Root length) except Number of leaves which obtained in second type of cultivar (C3), this is due to some walnut cultivars, including the Hawraman variety, may have genetic traits that promote faster germination. These traits could include a shorter dormancy period for the seed or genetic adaptations that facilitate quicker sprouting [1]. Moreover the seeds of this cultivar had a greatest weight of seed with an average weight of (13.99 gr) per seed.

This study identifies peat moss-media as the optimal growing medium for walnut seedling development, particularly when paired with the Hawraman cultivar. These findings provide practical recommendations for walnut propagation in nurseries and for reforestation projects in the Kurdistan region. Future studies should explore the long-term performance of these seedlings in field conditions to verify their suitability for large-scale reforestation efforts.

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