Effect of seeds densities on growth and biomass production of Sprouted barley By using hydroponic system

Yarub Samer Ahmed Alnuimy[1*], Azhar Idrees Dhnnoon Khattab[2], Muqdad daham jasim aljbory[3] , Omar Ahmed Fathi Al-Rubaie[4] , Haneen M. Ahmed[5] and Ali M. Saadi[5]
[1]Department of Plant Production Technologies, Technical Agricultural College, Mosul Northern Technical University, Mosul, Iraq.
[2] Biotechnology and Food Sciences, Technical Agricultural College, Mosul Northern Technical University, Mosul, Iraq
[3]Department of Electrical Engineering Technologies, Hawija Polytechnic College , Mosul Northern Technical University, Mosul, Iraq.
[4]Department of Desertification Combat Technologies, Technical Agricultural College, Mosul Northern Technical University, Mosul, Iraq
[5]Department of Animal Production Technologies, Technical Agricultural College, Mosul Northern Technical University, Mosul, Iraq.
*Corresponding author's email: yarub.sa@ntu.edu.iq

Abstract
The experiment was conducted in Nineveh Governorate, northern Iraq, during August 2025 in a germination chamber to evaluate the effect of Different seeds densities on the growth rate and performance of three barley cultivars grown By using hydroponic system. The seed density coefficients per square meter were 5 kg for the high seeds density treatment and 4 kg, 3 kg, and 2 kg for the low seed density treatment. The three cultivars (Abaa 265, Rayhan 3, and Samir) were evaluated for plant height, root length, fresh weight, and seed conversion ratio. the results showed Rayhan 3 was a significantly Superiority compared with Samir in plant height, with an average plant height of 16.60 cm. Rayhan 3 also a significantly Superiority compared with Abaa 265 in average root length, with an average root length of 5.20 cm. As for fresh weight, Rayhan 3 and Abaa 265 outperformed Samir, with an average fresh weight of 2.225 kg.tray^{-1} for both. In the conversion factor, the Rayhan 3 cultivar was significantly superior to the two cultivars, Abaa 265 and Samir, with an average conversion factor of (8.37). The difference was significant in the fresh weight trait for the highest seed rate (5 kg.m^{-2}), as it outperformed the rest of the seed rates. In the conversion factor, the seed rate (4 kg.m^{-2}) outperformed the other rates. The best performance was in the interaction between the Rayhan 3 cultivar and the seed rate (3 kg.m^{-2}), recorded an average plant height of (17.10 cm). As for root length, the Rayhan 3 cultivar and the seed rate (kg.m^{-2}) was the best, recording an average root length of (5.86 cm). As for fresh weight, the interaction between Abaa 265 and the seed rate (5 kg.m^{-2}) and the Samir cultivar and the seed rate (5 kg.m^{-2}) outperformed the rest of the interactions. The intercropping of basil 3 with seeding rate (4 kg.m^{-2}), (3 kg.m^{-2}), (2 kg.m^{-2}), and aba 265 with seeding rate (4 kg.m^{-2}) showed the highest values of conversion factor (8.86, 8.86, 8.81, and 8.78), respectively, without significant differences between them.
Keywords: *Hordeum vulgare* L., Green Fodder, Seeds densities.

Introduction

Barley (*Hordeum vulgare* L.) is one of the most important crops in the world, ranking fourth after wheat, rice, and maize. Global production exceeds 159 million tons across an area of 51 million hectares. Barley is a globally important crop, adapting to a wide range of environments and being stress-tolerant. Barley is also used as both human food and animal feed [10]. The availability of green fodder for livestock is declining due to

ISSN 2072-3857

the impact of climate change on crop productivity and the depletion of land and water resources Therefore, the production of green barley fodder in hydroponic systems could be an alternative to ensure sustainable production of green fodder for livestock. Its advantages include high nutritional and economic value, the use of a small area of land compared to traditional agriculture, and the provision of natural fodder for animals year-round A key advantage is the speed of green fodder production using hydroponic technology. [1]. Green fodder plants are of great importance in animal nutrition, as they meet their nutritional needs and enhance their appetite. Green fodder is also essential for increasing milk production and quality, especially in dairy cattle farming. Lack of agricultural space and environmental and climatic factors negatively impact agricultural production. The trend toward soilless farming is increasing due to the shortage of green fodder, which cannot be produced year-round. For this purpose, hydroponics is believed to help eliminate negative environmental and soil factors, ensuring the continuity of green fodder production year-round and reducing feed costs [5]. Results indicate that hydroponics had the potential to significantly reduce reliance on arable land, mitigate environmental degradation, and support urban agriculture [3]. The main benefits of hydroponics include efficient resource management, particularly water and space; increased yields thanks to controlled environments; and reduced pesticide use, leading to sustainable agricultural practices. Hydroponics can play a key role in improving food production [9]. Varieties vary in their response to hydroponic seeding rates [11]. In their study, a 3 kg concentration was found to be superior in the following traits: plant height, root length, fresh weight, dry weight, nitrogen content, protein content, and fiber content. Meanwhile, a 2 kg concentration was superior to other concentrations in carbohydrate content. The Abaa99 variety showed the highest average plant height, root length, fresh weight, and dry weight.

Material and Methods

Study site

The experiment was conducted in Nineveh Governorate, during August 2025 in a germination chamber to evaluate the effect of different Seeds densities on the growth ~~rate~~ and characteristics of three barley cultivars grown in a hydroponic system.~~.~~

Experimental Experimental design and Statistical Analysis

in a room at 20° to 22°C, with natural light provided through a window and artificial lighting from four 60-watt white lamps, operating for 18 hours per day. Water sprinklers operated for 2 minutes every two hours throughout the cultivation period. Iron and polyethylene shelves measuring 45 cm x 300 cm were used to hold the germination trays. The shelves were placed in the room at a height of one meter above the ground. Plastic trays measuring 45 cm length x 25 cm width x 4 cm height were used for seed germination. The experiment was conducted using a Completely Randomized Design (C.R.D.) with three replicates. The first treatment was three barley varieties (Abaa 265, Samir, Rayhan 3) shown in Table (1) and the second treatment was four seeds densities (5, 4, 3, 2) $kg.m^{-2}$, i.e. (400, 320, 240, 160) $g.tray^{-1}$. The seeds were washed to remove floating and foreign matter, then The seeds were also soaked in water for 12 hours and then left to air dry for half an hour. The seeds were placed in culture trays and distributed on shelves in the culture room. Eight days after planting, samples were collected from the culture trays, along with their intertwined roots, stems, and Leaves.

Studied Characters and Measurements

To study plant height, root length, and fresh weight, the fresh weight of the entire plant and the conversion ratio (the ratio of barley sprouts produced to the weight of the first-planted

ISSN 2072-3857

seeds) were recorded. Water was used for irrigation only. Duncan used and analyzed the data according to a completely randomized design (C.R.D.). [4]

Table (1) Database of Barley varieties used in the study [8].

variety protection	The deduced institution	Decision date	Committee decision	Barley variety
Free	Aba Center for Agricultural Research	24/10/2001	Registration and accreditation	Abaa 265
Free	Aba Center for Agricultural Research	30/10/1993	Registration and accreditation	Rayhan 3
Free	Iraqi Atomic Energy Organization	30/10/1993	Registration and accreditation	Samir

Table (2). Symbols of the treatments under investigation.

The symbol	seeding rate	The symbol	Variety
W1	5 kg.m^{-2}	V1	Abaa 265
W2	4 kg.m^{-2}	V2	Rayhan 3
W3	3 kg.m^{-2}	V3	Samir
W4	2 kg.m^{-2}		

Results and Discussion

Plant Height (cm)

The results in Table (3) showed significant differences between genetic varieties in plant height. Variety V2 significantly outperformed variety V3 with an average height of 16.60 cm. The difference between variety V1 and variety V3 was not significant The superiority of the V2 variety can be attributed to its genetic ability to increase plant height. This is consistent with [2] , where significant and insignificant differences were found in plant height across different varieties. Regarding seeding rates, there were insignificant differences in average plant height, ranging from 15.56 to 16.37 cm. This indicates that increasing seed density did not negatively affect the Barley seedling elongation within the range of rates used in this study. This is consistent with [7], where significant and insignificant differences were found in plant height at different seeding rates. The interaction between the factors had a significant effect on plant height. Treatment V2W3 recorded the highest value (17.10 cm), while treatment V1W4 produced the lowest value (14.90 cm), with a significant difference between them. It was noted that cultivar V2 maintained good height even with increased seeding rates (W3 and W4), while cultivar V1's height decreased significantly at the highest seeding rate. This suggests that cultivar V2 may have a better competitive advantage over resources when plant density increases. This is consistent with the findings of [11].

ISSN 2072-3857

Table (3) Plant height (cm) for the studied cultivars at different seeding rates.

Plant Height (cm)				
Varieties / seeding rate	V1	V2	V3	Average seeding rate
W1	16.40abcd	16.13abcd	15.63abcd	16.05a
W2	17.03ab	16.40abcd	15.70abcd	16.37a
W3	15.30bcd	17.10a	16.16abcd	16.18a
W4	14.90c	16.76abc	15.03cd	15.56a
Average varieties	15.90ab	16.60a	15.63b	

Means followed by different letters in each column differ at probability = 0.05.

Root Length (cm)

Results in Table 4 show significant differences in root length between the different varieties. Variety V2 achieved the highest average root length (5.20 cm), followed by variety V3 (4.70 cm), with no significant difference between them. Both significantly outperformed variety V1, which recorded the lowest average root length (3.62 cm). This may be attributed to the ability of each variety to increase cell division and expansion in the root system. Similar to plant height, the different seeding rates showed no significant effect on the average root length, with average values ranging from 4.16 to 4.82 cm. This suggests that root development was more dependent on the cultivar's genetic makeup than on seed density. This is consistent with [7], where significant and insignificant differences were found in root length at different seeding rates. The results of the interaction between cultivars and seeding rates also showed significant variation, with the V2W2 treatment recording the longest roots (5.86 cm), significantly outperforming most other treatments. In contrast, treatment V1W3 produced the shortest roots (3.40 cm). It was noted that cultivar V1 showed a marked decline in root growth at all seeding rates, reflecting a genetic limitation in root system development. This is consistent with the findings of [11].

Table (4) Root length (cm) for the studied cultivars at different seeding rates.

Root Length (cm)				
Varieties / seeding rate	V1	V2	V3	Average seeding rate
W1	3.53de	5.76ab	5.16abc	4.82a
W2	3.56de	5.86a	4.10cde	4.51a
W3	3.40e	4.43bcde	4.66abcde	4.16a
W4	4.00cde	4.73abcde	4.86abcd	4.53a
Average varieties	3.62b	5.20a	4.70a	

Means followed by different letters in each column differ at probability = 0.05.

Fresh Weight (kg.tray^{-1})

Fresh weight is considered one of the most important productivity indicators in this study. The results in Table (5) showed that cultivars V1 and V2 recorded the exact same average (2.225 kg.tray^{-1}), significantly outperforming cultivar V3 (2.057 kg.tray^{-1}). Unlike the previous traits, seeding rate had a clear and decisive significant effect on fresh weight. The results showed a strong inverse relationship between seeding rate and fresh weight, with seeding rate W1 (high density) yielding the highest fresh weight (3.041 kg.tray^{-1}), followed by seeding rate W2 (2.617

ISSN 2072-3857

kg.tray^{-1}), then W3 (1.897 kg.tray^{-1}), and finally W4 (1.204 kg.tray^{-1}). The differences were significant between all rates. This is consistent with [**7**], where significant and insignificant differences in fresh weight were found at different seeding rates. When examining the interaction, treatments V3W1 and V1W1 emerged with the highest fresh weight values (3.185 and 3.159 kg.tray^{-1}), respectively, with no significant difference between them. In contrast, treatments V1W4 and V3W4 recorded the lowest values (1.120 and 1.075 kg.tray^{-1}). This pattern confirms that obtaining the highest fresh weight yield requires using the highest seeding rate (W1), regardless of the variety used. This is consistent with the findings of [11].

Table (5) Fresh weight (kg.tray^{-1}) of the studied varieties at different seeding rates.

Fresh Weight (kg.tray^{-1})				
Varieties / seeding rate	**V1**	**V2**	**V3**	**Average seeding rate**
W1	3.159a	2.781b	3.185a	3.041a
W2	2.791b	2.823b	2.237c	2.617b
W3	1.833d	2.128c	1.732d	1.897c
W4	1.120f	1.419e	1.075f	1.204d
Average varieties	2.225a	2.225a	2.057b	

Means followed by different letters in each column differ at probability = 0.05.

Conversion Coefficient

The conversion coefficient was an important indicator of the efficiency of using inputs and converting them into outputs (biomass). Table (6) showed that the V2 variety significantly outperformed the V1 variety with an average of 8.37, followed by V1 (7.80), and V3 (7.22). The differences were significant among all varieties, confirming the presence of clear genetic differences in resource use efficiency, as [6] obtained similar results. Regarding seed rates, the W2 variety yielded the best conversion coefficient (8.17), significantly outperforming W1 (7.59) and W4 (7.52), while not significantly different from W3 (7.90). This indicates that the medium plant density (W2) was optimal for achieving the highest efficiency in input conversion. Regarding interaction, treatments V2W3, V2W4, and V2W2 had the highest conversion coefficient values (8.86, 8.86, and 8.81), respectively, with no significant differences between them.

Treatment V3W4 recorded the lowest value (6.72). Remarkably, the V2 variety maintained a high conversion coefficient at almost all seeding rates, confirming its genetic superiority in this trait.

Table (6) Conversion coefficient for the studied varieties at different seeding rates.

				Conversion Coefficient
Varieties / seeding rate	**V1**	**V2**	**V3**	**Average seeding rate**
W1	7.86bc	6.95de	7.96b	7.59b
W2	8.72a	8.81a	6.99de	8.17a
W3	7.63bcd	8.86a	7.21cde	7.90ab
W4	6.99de	8.86a	6.72e	7.52b
Average varieties	7.80b	8.37a	7.22c	

Means followed by different letters in each column differ at probability = 0.05.

ISSN 2072-3857

Conclusion

Based on the results obtained, we recommend the following:

To achieve maximum fresh weight yield, it is preferable to use the Aba 265 or Samir variety with a high seeding rate.

To achieve the highest resource use efficiency (conversion ratio), it is preferable to use the Rayhan 3 variety with a low seeding rate.

Future studies are recommended on the economic feasibility of various variety and seeding rate combinations.

These results highlight the importance of choosing the appropriate combination of genetic variety and seeding rate to achieve desired production goals, whether maximizing productivity or improving resource use efficiency.

References

[1] Afzalinia, S., & Karimi, A. (2020). Barley Cultivars and Seed Rates Effects on Energy and Water Productivity of Green Fodder Production under Hydroponic Condition. Indian Journal Of Agricultural Research.

[2] Alemnew, Y., & Mekuriaw, Y. (2023). Effects of harvesting age and barley varieties on morphological characteristics, biomass yield, chemical composition, and economic benefits under hydroponic conditions in Fogera District, Ethiopia. Advances in Agriculture, 2023(1), 9315556.

[3] Anjali, Singh, K., Thomas, R. R., Shubhashish, S., Kumar, S., & Kaushal, S. (2025). Hydroponics: An Innovative Approach to Sustainable High-Value Crop Cultivation. Journal of Scientific Research and Reports, 31(4), 410–419. https://doi.org/10.9734/jsrr/2025/v31i42961

[4] Antar, Salem Hamadi and Adnan Hussein Al-Wakkah (2017). Statistical analysis of agricultural experiments using SAS software. National Library and Documentation House, Baghdad, Deposit Number 2464.

[5] Boğa, M., Kılıç, H. N., Bulut, M., & Çanga, D. (2023). Use of Some Forage Plants Produced by Hydroponic System in Ruminant Animal Nutrition. Hayvan Bilimi ve Ürünleri Dergisi, 6(1), 103-113.

[6] Emam, M. S. A. (2016). The sprout production and water use efficiency of some barley cultivars under intensive hydroponic system. Middle East Journal of Agriculture Research, 5(2), 161-170.

[7] Gumus, H., & Kowalczuk-Vasilev, E. (2024). Effect of different sowing densities on biomass production and nutritive value of barley green fodder grown in a hydroponic system. Agronomy Science, 79(3).

[8] Iraq Ministry of Agriculture. (2024, January 24). List of approved vegetable varieties in Iraq. Retrieved from https://storage.zeraa.gov.iq/2024/01/24/2024_01_24_11942614399.pdf

[9] Khatri, L., Kunwar, A., & Bist, D. R. (2024). Hydroponics: Advantages and challenges in soilless farming. Big Data Agric.(BDA), 6, 81-88.

[10] Kumari, S. G., Makkouk, K. M., & Najar, A. (2024). Barley. In Viral Diseases of Field and Horticultural Crops (pp. 55-61). Academic Press .

[11] Mohsen, M. H., & Mahmood, R. S. (2025, April). Different Fulzyme Concentrations Effects on Different Barley Cultivars to Increase the Production of Green Forage under Hydroponic System. In IOP Conference Series: Earth and Environmental Science (Vol. 1487, No. 1, p. 012093). IOP Publishing.

ISSN 2072-3857