

Evaluating the process of disseminating tissue culture technology for date palms in Diyala province

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Abstract

Objective

Date palm cultivation and date production hold a prominent position in the agricultural sector in terms of exports, in addition to local consumption and industrial use, as they are used in food industries and feed manufacturing. This study aimed to evaluate the dissemination of tissue culture technology for date palms in Diyala Governorate in terms of planning, organization, implementation, and evaluation, and to identify the reactions of date palm orchard owners regarding the application of tissue culture technology in Diyala Governorate.

Materials and methods

The study sample consisted of 113 date palm farmers. A diagnostic research approach was used to evaluate the process of disseminating date palm tissue culture (DPTC) technology in Diyala Governorate in terms of planning, organization, implementation, and evaluation to achieve the first objective. A field research approach was used to achieve the second objective by employing a questionnaire as a means to obtain information from the respondents using a tripartite scale (Agree, Somewhat Agree, and Disagree) to measure the reactions of date palm farmers towards the application of tissue culture technology. The following scores were assigned to the scale statements (1, 2, 3) respectively, with 24 items identified.

Results

The results showed that the planning for the dissemination process of tissue culture technology is based on a sequence from planning, diagnosis, expansion, evaluation, and that the greatest effort was expended on the preparatory and organizational stages. The results also indicated that tissue culture technology is an effective and scientifically promising technology that has contributed to increasing the number of produced offshoots, improving the quality and health of date palms, in addition to developing the genetic and productive characteristics of date palms. However, the field expertise of the respondents was not at the required level, and date palm farmers still need more support and expertise in this field.

Conclusion

The study recommended the necessity of working to enhance extension programs, support the field expertise of the respondents, and focus on training personnel and dividing roles and responsibilities.

Keywords: agricultural extension, date palm, dissemination, tissue culture technology

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Introduction

The agricultural sector is one of the most important productive sectors in the economies of the majority of countries, generally, and developing countries in particular, including Arab nations. This is because agriculture plays a fundamental role in raising the living and social standards of the population. Consequently, the development of this sector requires a transition and shift from traditional production methods to scientific production methods based on the results and recommendations of scientific research. Most countries of the world, including the Arab world and Iraq, have adopted methods and means for its development and advancement. Among these is the use of modern agricultural technologies, both plant and animal, to provide diverse sources of food crops, including dates, for their various uses by all members of society (Albadry & Badr, 2025). Date palm cultivation and date production hold a prominent position in the agricultural sector in terms of exports, in addition to local consumption and industrial use, as they are used in food industries and feed manufacturing. This is alongside the environmental role played by date palm trees in combating desertification and creating alternative sources for non-renewable resources like oil. Furthermore, date palm trees are closely linked to the life of the Iraqi family in terms of nutrition, contributing significantly to achieving food security in light of the country's population growth (Khalil and Jassim, 2025). Iraq seeks to increase date palm cultivation through a plan that includes planting one million offshoots of good global varieties. This comes as the sector has suffered from poor planning and management, a lack of government support, in addition to climate changes, diseases, agricultural pests, water scarcity, and the eradication of orchards (Al-Mayahi, 2022). Tissue culture is considered a means that has contributed radically to the development of various types of agricultural crops, which has cast its

shadow on national and global economic growth (Mehbub et al., 2022). Plant tissue culture technology is one of the most important advanced scientific and applied fields that can contribute to solving the problem of increasing demand for food. Through this technology, genetic improvement and hybridization of plants can be easily performed. This technology can contribute to achieving food security and protecting the environment simultaneously (Wijerathna-Yapa and Hiti-Bandaralage, 2023). The date palm is an evergreen plant with a single trunk that can reach over 30 meters in height. At the base of this trunk, in the early years of the palm's life, offshoots form. These are used as the source for plant parts through which date palms are propagated via tissue culture. The terminal bud (the growing apex) of the offshoots is used; it is the only bud for date palms and is referred to by farmers. Date palm seeds are not suitable as a means of propagation (Zhang et al., 2024). Therefore, the propagation method using tissue culture technology is one of the modern propagation methods. In it, a small plant part, a bud, a meristematic part, or pollen grains are used and cultivated in a sterile nutrient medium containing all the nutritional elements, hormones, and amino acids under suitable artificial conditions (Zaid, 2024). Consequently, employing plant tissue culture technology is of utmost importance and represents a rapid solution for propagating, rehabilitating, and compensating for degraded date palm orchards. The Ministry of Agriculture has relied in its plan on the expertise of the FAO and the Arab Organization for Agricultural Development, leading to the establishment of numerous tissue culture laboratories in the governorates of Iraq. These focus on cultivating rare varieties due to the suitability of the climatic conditions and the presence of appropriate cultivation requirements (Solangi et al., 2023; Benigno et al., 2025). Among the reasons for adopting tissue culture technology is the low number of offshoots produced by a single palm tree through traditional methods, the high cost of offshoots, especially those of high-quality and rare varieties such as Barhi and Medjool and the difficulty in handling and transporting offshoots from one area to another, or from one country to another, due to the potential risk of them being infected with diseases and agricultural pests such as dubas bug, red palm weevil, and various borers. Additionally, the success rate of traditionally planting offshoots is low (Abdelghaffar et al., 2023). Furthermore, farmers resort to this method due to the limited number of offshoots growing on the mother palm, the scarcity or rarity of offshoots from some high-quality varieties, and the need to preserve their genetic traits. It also allows for obtaining plants in enormous quantities very quickly from date palm trees. Moreover, plants propagated this way have a greater ability to resist fungal diseases, such as Bayad/Bayoud disease which devastated Medjool date palm trees, and insects and agricultural pests like the red palm weevil, which recently entered Iraq. This method is also characterized by a shorter time to fruiting, where seedlings bear fruit within (2-4) years after being planted in their designated land. Furthermore, propagation through this method leads to a reduction in the price of offshoots, making them affordable for small-scale farmers at acceptable prices (Zaid, 2024). Given the importance and advantages of disseminating date palm tissue culture (DPTC) technology and the country's need to develop date palm cultivation, date productivity, increase yields, and ensure their sustainability, the Ministry of Agriculture initiated the process of disseminating this technology across most of the country's governorates (Tabei and Muranaka, 2020). This initiative aims to achieve agricultural development based on interaction

and cooperation between agricultural extension services, scientific research, and farmers. The technology is transferred to date palm farmers through the agricultural extension system, whereby modern and suitable agricultural technologies are generated for their farming systems to be widely disseminated among farmers through a clear and reliable operational framework that can be used for guidance, without overlooking the supporting role of input supply institutions (Yang et al., 2020). Agricultural extension is considered the foundation of agricultural development due to its role in the process of agricultural technology transfer across various stages. This process begins with introducing the technology, training farmers on its use, and equipping them with the necessary information and skills, which must be suitable for their farming systems, in addition to encouraging them to adopt it. Active participation in the planning, implementation, and evaluation processes, the ultimate goal is the dissemination, adoption, and localization of the technology within the farming systems of the target groups, ensuring it meets farmers' needs. Due to the importance and novelty of this subject, and aiming to keep pace with the scientific trend in using modern technologies, this study was conducted to evaluate the process of disseminating DPTC technology. This research represents one of the first analytical studies in Iraq addressing the dissemination and effectiveness of tissue culture technology in date palm cultivation. It provides a comprehensive evaluation of its organizational, technical, and extension dimensions, highlighting the role of institutional frameworks and farmer participation in ensuring sustainable technology adoption.

Materials and methods

A diagnostic research approach was used, falling under the descriptive methodology, which is deemed suitable for obtaining data related to the phenomenon under study at a specific time (Broom, 2006). This pertained to evaluating the process of disseminating DPTC technology in Diyala Governorate in terms of planning, organization, implementation, and evaluation. A field research approach was also employed to achieve the objectives of the current research, as it is considered appropriate for obtaining data in this field (Cho et al., 2023). This approach is a branch of the descriptive methodology in social research (Mertens, 1998). Diyala Governorate, with its districts and sub-districts, was selected as the area for conducting this research. The number of orchards planted using tissue culture technology reached 113 orchards (Table 1). Data regarding the evaluation of the planned and implemented process for disseminating Tissue Culture Technology by the Diyala Governorate Agriculture Directorate and its affiliated agricultural units for the years 2022-2025 was collected through personal interviews with the Director of Agriculture in Diyala Governorate, the directors of the affiliated agricultural units, and those responsible for disseminating Tissue Culture Technology during the years 2022, 2023, 2024, and 2025 (including management staff and researchers) from the Training and Extension Center in Diyala Governorate. Additionally, annual documents and reports related to the dissemination process of Tissue Culture Technology in Diyala Governorate, issued by the Planning Department, Follow-up Department, Plant Production Department, and the Horticulture and Forestry Division, were utilized. A questionnaire was also used as a means to obtain information from the respondents due to its suitability for the nature of the research and the required data.

Questionnaires are considered an appropriate tool for data collection as they offer greater objectivity than other specific data collection methods for achieving research objectives. The questionnaire was developed after reviewing. For example, scientific literature related to date palms and the use of modern technologies and innovations to develop this important sector, research and studies in the field of date palm cultivation, especially DPTC, and the opinions of a group of field specialists in horticulture, date palm cultivation, and agricultural extension, as experts are a fundamental source in building the measurement scale. In light of the above, the researcher prepared a questionnaire comprising 24 items to determine the reactions of date palm orchard owners in the governorate towards the application of DPTC Technology.

Table 1. The number of tissue-cultured orchards in Diyala Governorate

Agricultural Subdivision in Diyala Governorate	Number of Tissue-Cultured Orchards
Baquba Center	9
Muqadiyah	4
Dar Al-Salam	2
Al-Khalis	11
Al-Mansuriyah	10
Bani Saad	0
Mandalī	3
Abi Saida	3
Al-Saadiyah	0
Kanaan	6
Bahriz	17
Balad Ruz	14
Al-Wajihyah	12
Khanaqin	13
Qazaniyah	3
Hibhib	4
Qara Tappa	2
Jalawla	0
Al-Azeem Dam	0
Mohammed Sakran	0
Jabara	0
Total	113

The face validity of the scale was examined by presenting it, after the instrument's development, to a group of agricultural extension experts to assess face validity, and to experts and specialists in horticulture and DPTC to assess content validity. A preliminary test was conducted in July 2025 on a sample of 10 respondents taken from orchard owners applying tissue culture technology in the governorate. These respondents were excluded during data collection. The questionnaire's reliability was measured using Cronbach's alpha, and the reliability coefficient was 0.94. All items demonstrated high reliability. Data was collected during the period from July 2025 to August 2025 through personal interviews. The researcher used a tripartite,

graded scale consisting of levels of agreement (Agree, Somewhat Agree, Disagree). Weights of (1, 2, 3) were assigned respectively to all 24 items, in order to determine the reactions of date palm orchard owners in the governorate towards the application of tissue culture technology. The total possible scores on the scale ranged between 24 and 72 points. The weighted mean and percent weight were calculated for each item in the questionnaire.

Results and discussion

The total number of key components included in the DPTC technology diffusion plan in Diyala province for different years is given in Table 2.

Table 2. The components of the plan for disseminating tissue culture technology in Diyala Governorate for the years 2022, 2023, 2024, and 2025

Plan components for disseminating tissue culture technology for date palms	Number in 2022	Total in 2022	Number in 2023	Total in 2023	Number in 2024	Total in 2024	Number in 2025	Total in 2025
1. Identifying areas targeted for tissue culture date palm cultivation	4	8	7	12	12	20	18	34
2. Identifying date palm farmers targeted for tissue culture	30	60	45	96	62	115	71	120
3. Collecting data and information about the area and farmers targeted for tissue culture	1	2	5	8	9	15	13	20
4. Identifying problems and needs by priority for date palm farmers in the area	8	16	11	15	18	32	22	40
5. Preparing a written plan defining the responsibilities and duties of researchers and agricultural extension agents	2	4	6	12	8	15	12	21
6. Testing tissue culture in the area under the supervision of the researcher (agricultural extension agent)	1	2	3	5	5	10	8	15
7. Selecting sites for conducting tissue culture experiments representative of the targeted area	2	4	5	5	0	0	1	2
8. Selecting farmers whose farms will implement tissue culture	0	0	2	1	7	13	8	15
9. Confirming tissue culture results in multiple locations among date palm farmers	0	0	0	0	5	10	6	10
10. Making modifications and improvements to tissue culture technology to suit farmers' conditions	0	0	0	0	2	4	5	8
Total	48	96	84	158	126	230	164	285
Percentage (%)	50%		53.1%		54.7%		57.5%	

The results showed that the activities of the diffusion plan for the tissue culture date palm in Diyala Governorate were implemented by 50% in 2022, 53.1% in 2023, 58.6% in 2024 and by 57.5 % as percentage implementation for each year respectively. This shows just how gradualist the program was. The approach was identification on and diagnose in 2022 and 2023, with intensified expansion in 2024 and consolidation and sustainability in 2025. A main priority was given to preparation (identifying areas, selecting farmers; collecting data and identifying problems) and the plan reached out to several types of farms to assure that the technology would reach a maximum number of beneficiaries. Additionally, the attachment results suggest that 120 activities ranked first in terms of the second component and "Identifying date palm farmers targeted for tissue culture technology" item, meaning that this highest interest priority was placed on choosing appropriate sites. The fourth item ("Identifying problems and needs prioritized for date palm farmers in the area") was the second most frequent activity (40 activities), which is crucial for finding solutions to problems faced by orchard owners according to their specific conditions. The first item ("Identifying target areas for DPTC") came in third with 34 activities. These three items reflect that the greatest effort was dedicated to preparation and diagnosis before expanding the application. From all the above, we can conclude that the planning for the dissemination process of tissue culture technology is based on a progression from planning, to diagnosis, then expansion, and finally evaluation. The greatest effort was expended on the preparatory and organizational stages, while field research and experimental activities were implemented to a lesser degree, possibly scheduled for a later phase after broader coverage of a wide segment of farmers is achieved.

The total number of components included in the process of organizing the dissemination of DPTC technology in Diyala Governorate for the year 2022 was eight components, comprising 15 activities. Six activities were carried out, representing 40% of the total activities related to the process of organizing the dissemination of the technology. The total number of components included in the process of organizing the dissemination of DPTC technology in Diyala Governorate for the year 2023 was eight components, comprising 36 activities. Fifteen activities were carried out, representing 41.66% of the total activities related to the process of organizing the dissemination of the technology.

The total number of components included in the process of organizing the dissemination of DPTC technology in Diyala Governorate for the year 2024 was eight components, comprising 41 activities. 18 activities were carried out, representing 43.9% of the total activities related to the process of organizing the dissemination of DPTC technology in Diyala Governorate. Organization for Technology Dissemination. The total number of components included in the organization of the dissemination of DPTC technology in Diyala Governorate for the year 2025 was ten, encompassing 65 activities. 29 activities were carried out, representing 44.61% of the total activities related to the organization of technology dissemination (Table 3). It can be concluded that the activities included in the organization of the dissemination of DPTC technology in Diyala Governorate for the year 2022 were implemented at a rate of 40%, in 2023 at a rate of 41.66%, in 2024 at a rate of 43.9%, while in 2025 they were implemented at a rate of 44.61%.

Table 3. Components of organizing the process of disseminating tissue culture technology in Diyala Governorate for the years 2022, 2023, 2024, and 2025

Components of organizing the dissemination process of tissue culture technology	Number in 2022	Total in 2022	Number in 2023	Total in 2023	Number in 2024	Total in 2024	Number in 2025	Total in 2025
1. Planning and implementing training courses for agricultural extension agents	1	2	2	5	2	4	3	6
2. Planning and implementing experiments in farmers' fields	0	0	0	0	2	5	5	10
3. Participating in establishing field demonstrations for farmers	0	0	0	0	1	3	2	5
4. Participating in preparing extension bulletins and publications	1	2	1	5	2	4	3	7
5. Conducting field research and studies	0	0	0	0	0	0	1	0
6. Forming joint committees to develop technical recommendations for farmers	0	0	0	0	0	0	0	1
7. Dividing roles and responsibilities among researchers and extension agents	1	3	3	7	2	5	5	12
8. Allocating sites for researchers and extension agents to test tissue culture in the area	2	5	5	12	9	20	11	25
Total	6	15	15	36	18	41	29	65
Percentage (%)	40%		41.66%		43.9%		44.61%	

This indicates that the dissemination of tissue culture technology was not limited to field trials and visits, but rather relied on building an integrated organizational structure that included training, division of roles, and technical recommendations. In other words, the dissemination of DPTC technology was carried out according to a structured institutional approach, which focused on... Training staff, dividing roles and responsibilities, and preparing supporting guidance bulletins. The organizational aspect complements the executive aspect.

The total number of components included in the implementation plan for the dissemination of DPTC technology in Diyala Governorate for 2022 was 10, comprising 16 activities, of which 7 activities were implemented, representing 43.7% of the total planned implementation activities.

In 2023, the plan also consisted of 10 components with 36 activities, of which 16 were carried out, achieving a completion rate of 44.4%. For 2024, there were again 10 components that included 81 activities, of which 37 were implemented, equivalent to 45.6% completion. For the year 2025, the plan included ten items with 149 activities. A total of 70 activities were conducted, representing 46.97% of the implementation-specific activities (Table 4).

Table 4. Components of implementing the process of disseminating tissue culture technology in Diyala Governorate for the years 2022, 2023, 2024, and 2025

Components of implementing the dissemination process of tissue culture technology	Number in 2022	Total in 2022	Number in 2023	Total in 2023	Number in 2024	Total in 2024	Number in 2025	Total in 2025
1. Dividing the target area for tissue-cultured date palms into sub-areas	1	3	2	5	4	8	6	12
2. Conducting tissue culture experiments for date palms in multiple farms	0	0	1	0	0	0	3	7
3. Establishing demonstration fields under the supervision of the extension agent and researcher	1	2	3	7	2	5	5	10
4. Training local leaders in the region on tissue culture	0	0	2	4	3	7	8	19
5. Conducting follow-up visits to farmers' fields to gather their opinions about tissue culture	1	2	5	10	11	25	20	42
6. Holding field days on tissue culture of date palms in the governorate	0	0	0	0	3	6	5	11
7. Organizing seminars and extension meetings on tissue culture	1	0	0	0	3	7	6	12
8. Preparing scientific materials for TV and radio programs about tissue culture in date palms	0	0	0	0	2	4	4	9
9. Preparing extension bulletins and posters about tissue culture in date palms	2	4	1	3	4	9	5	11
10. Providing office and field consultations about tissue culture in date palms	2	5	3	7	5	10	8	16
Total	7	16	16	36	37	81	70	149
Percentage (%)	43.7		44.4		45.6		46.97	

The results indicate that the activities included in the plan for implementing the dissemination of DPTC technology in Diyala Governorate were executed at a rate of 43.7% in 2022, 44.4% in 2023, 45.6% in 2024, and 46.97% in 2025. This shows that the activities began with very limited steps in 2022 (with a small number of activities such as dividing target areas and preliminary visits). In 2023, gradual expansion began as activities increased in some areas like (field visits and agricultural trials). In the years 2024 and 2025, the volume of activities rose even more significantly, reflecting a cumulative, gradual plan for technology dissemination. The most frequently implemented activities were "Consecutive visits to farmers' fields to survey their opinions on tissue culture" item ranked first in terms of the number of activities (42 activities). This suggests that direct contact and field visits continue to be used as the main instrument of technology transfer; "Establishing demonstration fields under the supervision of the agricultural extension agent and researcher in farmers' fields" item consisted of 10 activities, an avenue through which to effectively demonstrate practical application of tissue culture; "Organizing extension seminars and meetings on tissue culture" item was a strong 12 activities that indicates the attention on knowledge of theory as well as practice.

In contrast, the activities that were least implemented included "Implementing DPTC trials in multiple locations within date palm farms" item. Although this method is among the most effective approaches for persuading farmers to adopt the technology, it recorded the lowest implementation rate. This indicates potential challenges in organizing trials across various sites, possibly arising from a shortage of qualified personnel required to execute the process or from limited resources, both human and material. As a result, demonstration fields were utilized as an alternative means to showcase the technology. "Holding field days on DPTC in the governorate" item was also implemented to a lesser extent compared to the more frequently executed continuous field visits. From these results, it can be concluded that there was a gradual strategy for disseminating DPTC technology, with a significant focus on field activities (visits and demonstrations) over experimental research activities.

For 2022, number of components included in the program to evaluate how it spreads DPTC technology in Diyala Governorate was ten, which include 131 activities. Among these, 62 activities were made and this is equal to 47.3% of all the procedure- related activities. For year 2023, the plan consisted of two components: a total of ten under which 209 activities fall. The number of activities executed in total 102 results in coverage of 48.8% of activity items from the evaluation list. For plan in 2024, there were 10 components, with a total of ten (275) activities. In the present study, 133 activities were performed, which accounted for 48.36% assessment-specific activities. For year 2025, the plan consisted of ten parts components which have 371 activities. A combined of 182 activities were implemented, constituting 49% of the assessment defined activities (Table 5).

The findings shown that activities for monitoring the spread of DPTC technology in Diyala Governorate was established by only 47.3% during the year 2022, indicating a poor start as an opening phase to gather primary data and tile evaluation tools. The adoption proportion was at 48.8% in 2023 with augmentation of the original number of activities and on describing the survey participants to identifying their needs.

Table 5. Components of the evaluation process for assessing the dissemination of tissue culture technology in Diyala Governorate for the years 2022, 2023, 2024, and 2025

Axes of the evaluation process for disseminating tissue culture technology	Number in 2022	Total number	Number in 2023	Total number	Number in 2024	Total number	Number in 2025	Total number
1.Verifying that data represent the actual facts in the target area	5	11	6	12	8	16	10	20
2.Suitability of the methods used for data collection	3	6	5	11	8	17	11	25
3.Accuracy in describing the target farmers (date palm growers)	8	16	9	20	11	25	10	20
4.The need of farmers (date palm growers) for tissue culture	4	9	8	18	14	30	16	32
5.Farmers' participation in defining the objective of disseminating DPTC technology	5	12	9	18	13	28	18	40
6.Objectives achieved by DPTC in the region	6	13	8	16	11	22	16	32
7.Number of farmers who believe that tissue culture is beneficial	15	30	30	60	35	70	50	100
8.Number of farmers who adopted DPTC in the governorate	4	8	8	16	11	22	15	30
9.Number of farmers who rejected DPTC in the governorate	2	6	3	6	2	5	1	2
10. Changes in farmers' application of scientific recommendations	10	20	16	32	20	40	35	70
Total	62	131	102	209	133	275	182	371
Percentage		47.3%		48.8%		48.36%		49%

It was 48.36% during 2024, in which activities have doubled obviously, due to more attention given to characterization of the farmers. In 2025 this rate was reached by 49%, showing a homogeneous and wide share of the loading to all activities included, which is becoming a stable stage in the program. This indicates that assessment was not just a side issue but it actually developed to be the center of measure for monitoring the plan. "Farmer's participation in the setting of objectives for the dissemination of DPTC technology" item led with 40 activities. This finding suggests that the project followed a participatory evaluation approach. "Objectives achieved by DPTC within the cluster area" item represented the second position, with 32 activities, indicating that measuring the achievement of objectives was a key issue. "The demand

on Tissue Culture Technology by the date palm farmers" item scored third (32 activities) that represents a trial to connect between "what is being done" and "what should be". "Appropriateness of the methods used for data collection" item placed fourth (25 activities), which is a good indicator of the adoption of a continuous review process for the tools and methodologies used. It can be concluded that the process of disseminating DPTC technology was not limited to just implementation and organization. It was accompanied by a continuous process of assessment and review, with a key characteristic being the essential role of farmer participation in the evaluation. This enhances the sustainability of the outcomes and the long-term acceptance of the technology. Based on the findings obtained, the research hypothesis stating that "The process of disseminating tissue culture technology in Diyala Governorate was not fully carried out in all its stages: planning, organization, implementation, and evaluation" is rejected.

The results showed that the reactions of date palm orchard owners regarding the results achieved from the application of date palm tissue culture technology obtained weighted averages ranging between 2.83-1.96 and percent weights ranging between 94.33-65.33, as detailed in the Table 6.

Table 6. Illustrates the respondents’ reactions regarding the results achieved from applying date palm tissue culture technology

Questionnaire Item No.	Rank	Statements	Weighted Average	Percent Weight
1	1	Tissue culture has contributed to increasing the number of palm trees in the governorate.	2.83	94.33
7	2	Tissue culture has contributed to obtaining rare date palm cultivars.	2.80	93.33
2	3	Tissue culture has contributed to obtaining a high-quality product.	2.78	92.66
9	4	I have a strong desire to continue using date palm tissue culture to develop my orchard.	2.66	88.66
3	5	It has contributed to increasing the productivity of the date palm.	2.38	79.33
6	6	It has contributed to obtaining cultivars resistant to environmental conditions.	2.36	78.66
5	7	It has contributed to obtaining productivity within a short period.	2.31	77.00
4	8	It has contributed to increasing economic returns compared to traditional cultivation.	2.04	68.00
8	9	It has contributed to improving my experience and skills in palm management.	1.96	65.33

The results revealed that the item “tissue culture has definitely contributed to increased number of date palm trees in the governorate” ranked at the top with weighted average 2.83 and percent weight of 94.33. This indicates that the agricultural extension correspondents confirmed the popular propagation of tissue culture technology for date palm as well as its impact on increasing palm tree number of orchards in governorate’s growers. The item “Tissue culture has made it possible to get rare species of date-palms” was the second highest rated item with

weighted average of 2.80 and percent weight 93.33 ranked second. This suggests that this is a modern and high-quality method of propagation that has opened up access to the hard to source varieties via traditional methods of propagation. The item “Tissue culture has contributed to obtaining a high-quality product” ranked third, with a weighted average of 2.78 and a percent weight of 92.66%. This highlights the comparative advantage of tissue culture technology in producing genetically stable, disease-free palm trees, thereby improving production quality and minimizing losses. The item “I have a strong desire to continue using date palm tissue culture to develop my orchard” ranked fourth, with a weighted average of 2.66 and a percent weight of 88.66%. This reflects the respondents’ recognition of the importance of this technology in obtaining superior cultivars that produce rare, high-quality fruits. The item “Tissue culture has contributed to increasing the productivity of the date palm” ranked fifth, with a weighted average of 2.38 and a percent weight of 79.33%. This indicates an improvement in both the quantitative and qualitative aspects of palm production as a result of adopting this technology. The item “It has contributed to obtaining varieties resistant to environmental conditions” ranked sixth, with a weighted average of 2.38 and a percent weight of 78.66%. This demonstrates that tissue culture technology has been instrumental in developing new date palm cultivars with enhanced tolerance to salinity and drought. The item “It has contributed to obtaining productivity in a short period” ranked seventh, with a weighted average of 2.31 and a percent weight of 77.00%. This suggests that tissue culture has proven its efficiency in producing fruit-bearing palm trees within a relatively short timeframe. The item “It has contributed to increasing economic returns compared to traditional cultivation” ranked eighth, with a weighted average of 2.04 and a percent weight of 68.00%. This suggests that applying the technology has contributed to increased production and, consequently, increased economic returns from cultivating rare and high-quality varieties. The item “It has contributed to improving my expertise and skills in palm care” ranked ninth with a weighted average of 1.96 and a percent weight of 65.33. This indicates that date palm farmers still rely on their previous experience and need training on how to use this technology according to its specific scientific recommendations. From these results, it can be concluded that there is consensus among the respondents that tissue culture technology is an effective and scientifically promising technology that has contributed to increasing the number of produced offshoots, improving the quality and health of date palms, in addition to developing the genetic and productive characteristics of date palms. However, the field expertise of the respondents was not at the required level, and date palm farmers still need more support and expertise in this field.

The results showed that the reactions of date palm orchard owners regarding the availability as well as provision of tissue culture technology obtained weighted averages ranging between 1.38-2.22 as well as percent weights ranging between 74.00-46.00, given that detailed in the Table 7. It is clear that weight Factors For the item "Continuous availability of tissue-cultured date palms, not restricted to a specific time " with weighted average 2.22 as well as percent weight 74.00, it was found to be ranked first. This means that the owners of an orchard can now get tissue culture at any time and also it implies that production of tissue cultured palms is a never-ending process, so they will be available for purchase in any season.

Table 7. The respondents’ reactions regarding the provision of date palm tissue culture technology

Questionnaire Item No.	Rank	Statements	Weighted Average	Percent Weight
4	1	Continuous availability of tissue-cultured date palms, not restricted to a specific time.	2.22	74.00
3	2	I can obtain any quantity I desire of tissue-cultured date palms.	2.13	71.00
2	3	Availability of tissue-cultured date palms during the date palm planting seasons.	2.08	69.33
5	4	There are no administrative complications when receiving tissue-cultured date palms from the Directorate in the governorate.	1.53	51.00
1	5	Availability of tissue-cultured date palms in sufficient quantities in nurseries and at low prices.	1.39	46.33

The statement item “I can obtain any quantity I desire of tissue-cultured date palms” was in the second position of a high weighted mean 2.13 and percent weight 71.00. That presents a satisfying response from orchard owners who need the technology in amounts that are available to them, serving to reassure that their efforts made to provide this technology as well as meet their demands. The item “availability of tissue-cultured date palms during the date palm plantation seasons” scored third and weighted mean 2.08, percent weight 69.33 percent rank 3. This indicates that tissue cultured palms are available when farmers would require such plants during planting seasons ushering in a prospective schedule for the re-establishment of their orchards with improved varieties. The item "There are no administrative complications once receiving tissue-cultured date palms from the Directorate in the governorate" ranked fourth with a weighted average of 1.53 as well as a percent weight of 51.00. This points to the existence of some administrative complexities faced by respondents once receiving the tissue culture technology. The item "Availability of tissue-cultured date palms in sufficient quantities in nurseries as well as at low prices" ranked fifth with a weighted average of 1.39 as well as a percent weight of 46.33. This indicates that the respondents confirm that the quantity otherwise quality of palms in nurseries is insufficient, in addition to their high prices compared to those from government entities. From these results, it is clear that the respondents are satisfied with the availability of tissue culture technology in items 1, 2, 3, due to its good as well as continuous supply. However, there are some challenges related to administrative procedures as well as the availability of the technology in nurseries, given that seen in items 4 as well as 5. This indicates a positive orientation towards the technology, coupled with a need to improve administrative organization as well as institutional support. The results showed that the reactions of date palm orchard owners regarding the extension services provided obtained weighted averages ranging between 2.82-2.38 and percent weights ranging between 94.00-79.33 (Table 8). It is clear that the item "Introducing date palm farmers to the importance of tissue culture in mitigating the effects of climate change" ranked first with a weighted average of 2.82 as well as a percent weight of 94.00. This indicates

that the majority of respondents emphasize the important role of agricultural extension in raising awareness about modern technologies given that a means to adapt to climate change.

Table 8. illustrates the respondents' reactions regarding the extension services provided to orchard owners

Questionnaire Item No.	Rank	Statements	Weighted Average	Percent Weight
5	1	Introducing date palm farmers to the importance of tissue culture in reducing the effects of climate change.	2.82	94.00
2	2	Developing extension programs to improve and enhance the skills, knowledge, and experience of date palm farmers regarding tissue culture.	2.81	93.66
3	3.5	Holding educational seminars on the importance of date palm tissue culture and its role in increasing productivity.	2.78	92.66
4	3.5	Providing extension lectures on tissue culture technology and its ability to resist diseases.	2.78	92.66
1	4	Holding extension seminars on modern methods for establishing tissue-cultured orchards to obtain globally and commercially desirable cultivars.	2.77	92.33
7	5	Conducting field visits to diagnose the problems faced by tissue-cultured date palm farmers.	2.76	92.00
6	6	Organizing field demonstrations on the mechanization, maintenance, and harvesting of tissue-cultured date palms.	2.72	90.66
10	7	Providing lectures and field demonstrations on scientific methods for cultivating tissue-cultured date palms.	2.68	89.33
8	8	Holding extension meetings on protecting tissue-cultured offshoots from diseases, insects, and pests.	2.66	88.66
9	9	Following up on the application of tissue culture technology from production and marketing perspectives.	2.38	79.33

The item "Preparing extension programs to develop as well as improve the skills, knowledge, as well as expertise of date palm farmers regarding tissue culture" ranked second with a weighted average of 2.81 as well as a percent weight of 93.66. This shows that respondents stress the importance of training as well as extension programs that enhance their scientific as well as practical competence. The items "Holding educational seminars on the importance of date palm tissue culture as well as its role in increasing productivity" as well as "Providing extension lectures on tissue culture technology as well as its ability to resist diseases" shared the third rank with a weighted average of 2.78 as well as a percent weight of 92.66. This demonstrates that respondents assign great importance to seminars as well as lectures given that effective means for knowledge transfer as well as reinforcing practical understanding of tissue culture technology. The item "Holding extension seminars on modern methods for establishing tissue-cultured orchards to obtain globally as well as commercially desirable varieties" ranked fourth with a weighted average of 2.77 as well as a percent weight of 92.33. This reveals an interest among respondents in learning modern methods for establishing high-quality, high-productivity tissue culture farms.

The item "Conducting field visits to diagnose problems faced by farmers of tissue-cultured date palms" ranked fifth with a weighted average of 2.76 as well as a percent weight of 92.00. This underscores the importance respondents place on field visits as well as their role in identifying challenges specific to this technology. The items "Field demonstrations on the mechanization, maintenance, as well as harvesting of tissue-cultured date palms" as well as "Providing lectures as well as field demonstrations on scientific methods for cultivating tissue-cultured date palms" ranked sixth as well as seventh with weighted averages of 2.72 & 2.68 as well as percent weights of 90.66 & 89.33, respectively. This highlights the value placed on hands-on field work for skill development, alongside the role of lectures in providing correct information on scientific cultivation methods. The item "Holding extension meetings on protecting tissue-cultured offshoots from diseases, insects, as well as pests" ranked eighth with a weighted average of 2.66 as well as a percent weight of 88.66. This points to the importance of extension services in providing sufficient information on prevention as well as scientific treatment methods for pests as well as diseases. The item "Follow-up on the application of tissue culture technology from production and marketing perspectives" ranked last with a weighted average of 2.38 and a percent weight of 79.33. This indicates a weakness in field follow-up and continuous supervision after the implementation of tissue culture. From all the above, we conclude that the extension services provided to date palm farmers using tissue culture technology achieved good scores, but they require improvement and enhanced follow-up. Based on the findings obtained, the research hypothesis stating that "Date palm orchard owners in Diyala Governorate have negative reactions towards the application of date palm tissue culture technology" is rejected.

Conclusions: Based on the research findings, it can be concluded that the planning for disseminating tissue culture technology is based on a gradual progression starting from planning, proceeding to diagnosis, subsequently to expansion, and ultimately to evaluation. The greatest effort was expended on the preparatory as well as the organizational stages compared with field research and experimental activities. The dissemination process of tissue culture technology was not confined to field trials or visits; rather, it relied on building an integrated organizational structure comprising training, role distribution, as well as technical recommendations. Essentially, the technology was disseminated within an institutional framework. There is a gradual strategy for disseminating date palm tissue culture technology, with a significant focus on field activities, such as visits and demonstrations more than experimental research efforts. It employs direct communication as well as field meetings as the main tool for dissemination, emphasizing both theoretical understanding as well as practical implementation. The dissemination process of date palm tissue culture technology was not restricted solely to implementation or organization; instead, it was accompanied by a continuous process of evaluation as well as review, with farmer participation being a core element of assessment. There is consensus among the respondents that tissue culture technology is an effective and scientifically promising innovation that has contributed to increasing the number of produced offshoots, improving the quality as well as the health of date palms, in addition to enhancing their genetic and productive traits. The respondents expressed satisfaction regarding the availability of tissue culture technology given its steady as well as consistent supply. Nevertheless, some administrative challenges together with nursery

availability issues remain. This reflects a positive orientation toward the technology, alongside a need for stronger administrative organization and institutional backing. The extension services provided to date palm farmers adopting tissue culture technology received good evaluations; nevertheless, they still require further improvement together with continuous follow-up.

Authors' contribution

The author was responsible for designing the study, collecting and analyzing the data, and interpreting the results. The author also wrote, revised, and approved the final manuscript for publication.

Data availability

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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Ethical considerations

Not applicable.

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Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this research.

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ارزیابی فرایند گسترش فناوری کشت بافت نخل خرما در استان دیاله

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چکیده

هدف: کشت نخل خرما و تولید خرما در بخش کشاورزی از نظر صادرات، مصرف داخلی و کاربردهای صنعتی جایگاه مهمی دارد، زیرا در صنایع غذایی و تولید خوراک دام مورد استفاده قرار می‌گیرد. هدف این مطالعه ارزیابی میزان گسترش فناوری کشت بافت نخل خرما در استان دیاله از نظر برنامه‌ریزی، سازماندهی، اجرا و ارزیابی، و همچنین شناسایی واکنش صاحبان باغ‌های نخل نسبت به کاربرد این فناوری در استان دیاله بود.

مواد و روش‌ها: نمونه پژوهش شامل ۱۱۳ نفر از کشاورزان نخل کار بود. برای دستیابی به هدف اول، از رویکرد پژوهش تشخیصی جهت ارزیابی فرایند گسترش فناوری کشت بافت نخل خرما (DPTC) در استان دیاله از نظر برنامه‌ریزی، سازماندهی، اجرا و ارزیابی استفاده شد. برای دستیابی به هدف دوم، از رویکرد پژوهش میدانی بهره گرفته شد. در این راستا از پرسشنامه به‌عنوان ابزار جمع‌آوری داده‌ها از پاسخ‌دهندگان استفاده گردید و واکنش کشاورزان نخل کار نسبت به کاربرد فناوری کشت بافت با استفاده از مقیاس سه‌درجه‌ای (موافق، تاحدی موافق، مخالف) سنجیده شد. برای گویه‌های مقیاس به‌ترتیب امتیازهای (۱، ۲، ۳) در نظر گرفته شد و در مجموع ۲۴ گویه مورد بررسی قرار گرفت.

نتایج: نتایج نشان داد که برنامه‌ریزی برای فرایند گسترش فناوری کشت بافت بر اساس توالی مراحل شامل برنامه‌ریزی، تشخیص، توسعه و ارزیابی انجام می‌شود و بیشترین تلاش در مراحل مقدماتی و سازماندهی صرف شده است. نتایج همچنین نشان داد که فناوری کشت بافت یک فناوری مؤثر و امیدبخش از نظر علمی است که به افزایش تعداد پاجوش‌های تولیدی، بهبود کیفیت و سلامت نخل‌های خرما و همچنین توسعه ویژگی‌های ژنتیکی و تولیدی آن‌ها کمک کرده است. با این حال، تجربه میدانی پاسخ‌دهندگان در سطح مطلوب نبود و نخل‌کاران همچنان به حمایت و تخصص بیشتری در این زمینه نیاز دارند.

نتیجه گیری: این مطالعه توصیه می کند که برنامه های ترویج کشاورزی تقویت شوند، تجربه و مهارت های میدانی کشاورزان افزایش یابد، و بر آموزش نیروی انسانی و تقسیم مناسب نقش ها و مسئولیت ها تمرکز بیشتری صورت گیرد.

کلمات کلیدی: ترویج کشاورزی، فناوری کشت بافت، گسترش فناوری، نخل خرما

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