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Role of Fertigation in Improving Water and Nutrient Use Efficiency in Date Palm Cultivation and Production

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Abstract

Fertigation, the application of fertilizers with water through an irrigation system, has emerged as an effective approach to enhance nutrient and water-use efficiency in date palm. This review highlights current progress in applying the fertigation technique to improve date palm growth, yield, fruit quality, and sustainability in arid and semi-arid environments. The review covers various water-soluble fertilizers, their impact on nutrient availability in the soil around the roots, and different fertigation techniques. Beyond this, the review also highlights the roles of water conservation and environmental protection by minimizing nutrient loss and enhancing fertilizer management through fertigation. The technology-related constraints, such as water quality, emitter clogging, and management, are also reviewed. In general, the results of this study indicate that fertigation can be a potential technique for sustainable date palm production when combined with good irrigation and nutrient management practices.

Keywords: Fertigation, date palm nutrition, drip irrigation, water-soluble fertilizers, nutrient use efficiency.

Introduction

Date palms (*Phoenix dactylifera* L.) are a globally cultivated crop and a major agricultural commodity in many arid and semi-arid regions of the world, with both economic and cultural significance (Shareef *et al*., 2022). The actual temperature is better suited to hot conditions and low rainfall, which means they require adequate watering to achieve yield. To address this issue, fertigation has been suggested, as it allows nutrient applications to be synchronized with the growth phases of date palm, thereby increasing fertilization efficiency and improving crop performance (Dhaouadi and Haj-Amor, 2025). Fertigation is an agricultural technique that uses irrigation to deliver water-soluble fertilizers to the root zone of plants, ensuring they are applied quickly and with sufficient soil moisture (Ghosh *et al*., 2025). Such an innovative practice is now widely adopted because it can enhance both water and nutrient management simultaneously—very useful in parts of the world with limited access to irrigation. Fertigation is the combination of fertilization and irrigation (Ali, 2012) and refers to nutrient supply through this method, which also has moistening effects on crops. A fertigation system is an advanced approach that delivers fertilizers through irrigation media, offering scope for sustainable agriculture. Finally, one of the most important advantages of fertigation is that applying nutrients directly in the root zone minimizes nutrient losses through leaching and runoff, which are more common with conventional practices. Treatment of specific nutrients can support maximum plant growth and minimize environmental pollution associated with conventional fertilizers (Kaur *et al*., 2025). Rationalizing irrigation water consumption while mitigating environmental impacts is a pressing challenge in arid date palm cultivation, where water scarcity and salinity threaten productivity and ecosystem health. Fertigation offers a powerful strategy to address these dual concerns (Alhamd, 2024). First, fertigation synchronizes water and nutrient supply with the tree's actual physiological demand. Traditional flood or furrow irrigation often applies excessive water to ensure adequate nutrient distribution, leading to deep percolation, runoff, and leaching of nitrates and phosphates into groundwater (Sun et al., 2023). In contrast, drip‑based fertigation applies water directly to the root zone in controlled volumes, minimizing evaporation and eliminating over‑irrigation (Çetin & Akalp, 2019). For date palms, which have shallow but extensive root systems, this ensures that moisture and essential elements (e.g., nitrogen, potassium, and magnesium) are available precisely during critical growth stages—flowering, fruit set, and ripening. Consequently, overall irrigation water consumption can be reduced by 30–50%

compared to conventional methods without compromising yield or fruit quality (Mazahrih et al., 2018). Second, fertigation mitigates key environmental impacts associated with date palm agriculture. Salinization, which occurs when excess irrigation raises the water table and leaves behind salts as water evaporates, is reduced because efficient water delivery limits deep drainage and salt accumulation in the root zone (Farag et al., 2025). Controlled nutrient application also prevents fertilizer runoff, which can degrade aquifers and surface water bodies through eutrophication. Advanced fertigation systems allow the use of saline or brackish water—common in many date‑growing regions, such as the Middle East and North Africa—by adjusting fertilizer formulations and leaching fractions, thereby reducing pressure on freshwater resources and preserving natural ecosystems. Moreover, higher nutrient uptake efficiency means lower total fertilizer volumes are needed, which reduces greenhouse gas emissions from fertilizer production and transport (Alnajjar et al. 2020). In practice, rationalizing irrigation via fertigation in date palm orchards requires careful design: soil moisture sensors, evapotranspiration‑based scheduling, and periodic monitoring of electrical conductivity (EC) and pH in the root zone (Mazahrih et al., 2018). Split applications of nitrogen, for instance, can reduce nitrous oxide emissions compared to single heavy doses. The shift also encourages the use of biodegradable or controlled‑release fertilizers, further lessening environmental persistence. When combined with mulching or cover cropping, fertigation can improve soil structure and carbon sequestration, enhancing orchard resilience to climate change. Fertigation systems can thus provide functional solutions to address operational constraints, maintaining soil nutrient levels while reducing external crop inputs (Xing and Wang, 2024).

This literature review summarizes the features that contribute to the positive effects of fertigation in date palms and then describes the methods and requirements for applying this practice. This article presents selected case studies to demonstrate how fertigation can improve the productivity and agricultural sustainability of date palms in arid zones. In doing so, we underscore the need to practice resource-conserving crop management and sustainable production systems.

Fertigation vs Other Fertilization Methods

Fertigation is a method of delivering nutrients to crops through an irrigation system. A distinction is needed between fertigation, foliar spray fertilization, and ground fertilization in order to determine the appropriate technique for date palm crops. Key characteristics of each method for comparison are presented in Table 1.

Table 1. Comparison of Fertigation with Other Fertilization Methods

Feature	Fertigation	Foliar Spray Fertilization	Ground Fertilization
Application Method	Nutrients are mixed with irrigation water and delivered directly to the root zone via drip or sprinkler systems.	Nutrients are sprayed directly onto the leaves for immediate absorption.	Nutrients are applied directly to the soil surface or incorporated into the soil.
Nutrient Uptake Efficiency	Very high (up to 95%) due to direct root zone delivery.	Moderate to high, depending on leaf surface area and environmental conditions.	Variable, often lower due to leaching and runoff.
Water Usage	Low water consumption; synchronized with irrigation.	Environmental conditions such as humidity and temperature may influence absorption efficiency	A variable can lead to water waste if not managed properly.
Cost-Effectiveness	High; reduces fertilizer and water use, leading to lower overall costs.	Moderate; can be cost-effective for micronutrient applications but may require frequent applications.	Variable; initial costs can be high, and efficiency depends on soil conditions.
Environmental Impact	Low; minimizes runoff and nutrient leaching into waterways.	Moderate; potential for leaf burn and runoff if not applied correctly.	Higher levels can lead to nutrient leaching and groundwater contamination.
Labor Requirements	Moderate; requires setup and maintenance of irrigation systems.	High; often requires manual application and careful monitoring.	Variable; can be labor-intensive depending on application methods and soil preparation.
Best Use Cases	Ideal for water-sensitive crops, such as date palms, in arid regions.	Effective for quick correction of nutrient deficiencies; useful for micronutrients.	Best for establishing nutrient-rich soil conditions prior to planting.

Benefits of Fertigation

Enhanced Nutrient Efficiency

Fertigation delivers nutrients directly to the root zone, significantly improving fertilizer use efficiency compared to conventional broadcast or furrow application. Studies demonstrate that under controlled conditions—depending on the specific nutrient (e.g., nitrogen, phosphorus, or potassium), crop type (such as date palms), soil properties, and irrigation scheduling—uptake efficiencies can exceed those of traditional methods, often reaching very high levels (e.g., over 90% for nitrogen in drip-irrigated systems) (Sarma *et al*., 2023). This precise input matching minimizes fertilizer waste, reduces leaching losses, lowers farmers' input costs, and enables crops to perform at their optimal potential. However, reported efficiency values must be interpreted within the context of the experimental conditions, as they vary with nutrient mobility, root distribution, and environmental factors.

Water Conservation

Fertigation saves water and reduces leaching by synchronizing water with nutrient supply (Sood *et al*., 2025), an important benefit in areas with limited water resources. This is particularly important in regions with limited water resources, especially in arid and semi-arid environments, to make crop cultivation resilient to climatic stress.

Soil Health Preservation

Fertigation contributes to soil health by enabling precise, controlled nutrient delivery, reducing the risks of nutrient imbalance, salinity buildup, and leaching associated with conventional fertilization. It also supports better nutrient distribution in the root zone, promoting improved root development and soil conditions. When combined with organic amendments, fertigation may enhance soil organic matter, structure, and water-holding capacity, thereby supporting long-term soil fertility and sustainable agricultural production (Xing *et al*., 2025).

Environmental Protection

Fertilizer management reduces the pollution potential of groundwater, particularly nitrate levels that are deleterious to human health when drinking water from aquifers contaminated with fertilizers; therefore, reducing fertilizer leaching plays a positive role in reducing agriculture's negative impact on water resources (Singh and Craswell, 2021). Fertigation reduces the risk of nutrients leaching into waterways, safeguarding sensitive aquatic habitats and helping to prevent eutrophication.

Cost-Effectiveness

According to Adamo *et al*. (2025), when these benefits are combined, they can substantially reduce agricultural input costs by reducing fertilizer use, water consumption, and labor. Simply applying the required amount of fertilizer prevents resource waste and enhances benefits to farmers. This economic benefit plays an important role in attracting smallholder farmers who may have limited resources.

Enhanced Crop Resilience

Fertigation provides a steady supply of nutrients to plants, helps develop a consistent growth profile, and aids the cropping system in combating disease and pests (Sneha *et al*., 2025). In fact, this is a critical moment in date palm cultivation, and nutrient deficiencies increase the susceptibility to various plant pathogens, leading to reduced yield and quality.

Methods of Fertigation

This could occur indirectly through several modes of fertigation tailored to the requirements of agriculture:

Drip Irrigation

With this technique, fertilizers can be applied to the plant's root zone, and the nutrients remain available to the plant. Drip irrigation systems operate simultaneously, supplying water and nutrients, keeping plants in optimal growth conditions, which ultimately contributes to high efficiency (Al-Nawaiseh, 2025).

Spray Irrigation

Some fertilizers are also applied to the foliage of a target plant via the air for rapid nutrient uptake. In this method, a metric departure mechanism for micronutrients is designed, with the recipient consuming small amounts of them after the onset of apparent nutrient deficiency (Shareef *et al*., 2022).

Tank Mixing

Different fertilizers are usually mixed in water tanks before application, ensuring that the resulting solution has consistent chemical properties and that the compounds remain soluble and do not precipitate. This approach allows multiple fertilizers to be applied in a single fertigation event, thereby increasing nutrient diversity and balancing plant nutrient levels (Aisham and Rahim 2019). Proper mixing protocols—such as maintaining appropriate pH, avoiding incompatible fertilizer salts (e.g., calcium with sulfates or phosphates), and using sequential injection—are essential to prevent emitter clogging and ensure uniform nutrient delivery to the root zone.

Nutrient Considerations

Primary Nutrients

The high frequency of N application by fertigation and their low application rates for P, as very little is applied through fertigation due to precipitation, with the high concentrations of Ca and Mg present in the waters. Table 2: Examples of K nutrients that can also be applied in this way, with some macronutrients.

Table 2. Suitable fertilization method as fertigation for the primary nutrients of date palms

Nutrient	Function	Recommended Application Method	References
Nitrogen (N)	Promotes vegetative growth	Drip irrigation	Brewer *et al*. (2018)
Phosphorus (P)	Supports root development	Foliar spray	Görlach and Mühling (2021)
Potassium (K)	Enhances fruit quality	Drip irrigation	Ghazzawy *et al*. (2023)
Calcium (Ca)	Strengthens cell walls	Foliar spray	Shareef and ALarab (2025)
Magnesium (Mg)	Aids in photosynthesis	Drip irrigation	Salama *et al*. (2014)

Secondary and Micronutrients

Biofortification of iron (Fe), manganese (Mn), and zinc (Zn). These three micronutrients are the most critical overall for maximum growth (Ahmed *et al*., 2024). These can be applied through fertigation or foliar sprays to remedy deficiencies and ensure the plants have access to all required elements for success.

Fertigation Strategies

Nutrient Availability

Fertigation maximizes the availability of these essential nutrients to date palms. This approach requires scheduling and intensity based on suitable crop requirements at different growth stages (Ashrafi *et al*., 2020).

Fertigation Frequency

Typically, these Fertigation applications are done based on the crop growth stages. Previous studies indicate that split applications during the growing season can enhance nutrient use efficiency and minimize leaching losses. This method provides a continuous supply of nutrients, enabling uniform growth (Cai *et al*., 2023).

Monitoring Soil and Water Quality

For successful fertigation, soil and water quality must be monitored regularly. Soil nutrient levels and irrigation water quality are suitable for the types and rates of fertilizer being used. This type of proactive management aims to provide sufficient crop nutrition while reducing risk (Pibars *et al*., 2022).

Challenges and Solutions

Clogging: Calcium or magnesium at sufficiently high concentrations can cause phosphorus to precipitate, clogging our drip emitters. Frequent system flushing can alleviate this issue, and the addition of acidifiers can keep mineral deposits low while keeping the irrigation system operational (Dehghanisanij *et al*., 2025). Manganese ions (Mn^{2+}) have been shown to mitigate clogging issues associated with phosphorus fertilization in drip irrigation emitters (Xu et al., 2025). The proposed mechanism involves Mn^{2+} binding with phosphate ions to form soluble complexes or altering the crystallization kinetics of calcium phosphate precipitates—common clogging agents—thereby reducing their deposition within emitter channels. However, the extent of this effect depends on water quality parameters such as pH, bicarbonate concentration, and the presence of other divalent cations (e.g., Ca^{2+}, Mg^{2+}). Thus, while Mn^{2+} can reduce clogging risk, it is not a universal solution but rather one component of an integrated anti-clogging strategy for fertigation systems. Fertigation mitigates soil salinity in date palm orchards primarily by enabling precise, localized water application that minimizes deep percolation and capillary rise of saline groundwater (Suhim *et al*., 2017). Traditional flood irrigation often supplies excess water, raising the water table and drawing salts upward as water evaporates from the soil surface. In contrast, drip-based fertigation delivers water and fertilizers directly to the root zone at rates matching the palm's evapotranspiration demand, thereby reducing the upward movement of salts. Moreover, fertigation allows growers to apply a controlled "leaching fraction"—a small surplus of water that dissolves accumulated salts and carries them below the root zone without wasting significant water. The continuous, low-volume irrigation also maintains a stable soil moisture regime, preventing the extreme drying cycles that concentrate salts near the roots. Additionally, fertigation can be integrated with saline or brackish water by adjusting fertilizer blends (e.g., increasing calcium and magnesium) to counter sodium toxicity and improve root osmotic balance. Over time, these practices lower the electrical conductivity (EC) of the root-zone soil solution, enhancing date palm growth, fruit yield, and long-term orchard sustainability.

Fertigation Compatible – Incompatible Fertilizers

Fertilizers adapted to this type of use can also be highly soluble or compatible with the irrigation system, facilitating their application by drip irrigation and, in some cases, by foliar application. The nitrogen sources listed in numerous descriptions include urea, ammonium nitrate, and calcium ammonium nitrate for proper vegetative development, fruit fullness, and potential problems such as soil acidification (due to the calcium). Also, potassium nitrate provides a completely soluble, bioavailable nutrient source without chloride toxicity. Ammonium polyphosphate qualifies as a soluble phosphorus source, but caution is warranted, and it must be closely monitored during mixing and application due to its high potential for runoff. Instead, (suitable under specific conditions) fertilizers are mostly eliminated from the list because they create either operational or agronomic issues. Ammonium sulfate is not recommended in this case due to its potential to cause salinity hazards and plant toxicity. Feed-grade superphosphate, which is very soluble in water, and triple superphosphate will not be adequate for use because they may contain significant insoluble fractions, leading to clogging of irrigation emitters or sedimentation. A potassium chloride recommendation with its high salt index will be deleterious to yield and toxic to sensitive crops. Drip irrigation is used to prevent sodium ions from precipitating calcium nitrate; on the other hand, calcium nitrate is problematic since it can actually precipitate calcium out of fertigation water. Finally, the tables highlight that a successful fertigation track record requires the use of soluble fertilizers to reduce clogging risks and to mitigate the effects of terrestrialization and precipitation events. These fertilizers, divided into three categories: very appropriate, suitable, and unsuitable for the fertigation of date palm, are summarized in summary tables with their chemical analysis (Tables 3 and 4).

Table 3. Suitable Fertilizers in the Fertigation of Date Palm

Fertilizer Type	Description	Application Method	
		Drip irrigation	**Foliar spray**
Nitrogen Fertilizers	Highly soluble, promotes vegetative growth and fruits	(Mazahrih et al., 2018)	Murad and Al-Dulaimy (2021)
Calcium Ammonium Nitrate	Combines nitrogen and calcium, preventing soil acidification	(Jasim et al., 2016)	Jasim *et al*. (2016)
Urea Ammonium Nitrate	Liquid fertilizer with high nitrogen content	(Kassem, 2012)	El-Salhy *et al*. (2024)
Potassium Nitrate	Provides potassium without chloride toxicity	(El-Salhy et al., 2024)	Elsayd *et al*. (2018)
Ammonium Polyphosphate	Soluble phosphorus source, used with caution	(Chtouki et al., 2024)	Fasal *et al*. (2014)

Table 4. Not suitable Fertilizers in the Fertigation of Date Palm

Fertilizer Type	Reason for Unsuitability	References
Ammonium Sulfate	High risk of salinity and potential toxicity to plants	Buck *et al*. (2020)
Superphosphate	Contains insoluble forms that can clog emitters	Muhammad *et al*. (2021)
Potassium Chloride (KCl)	A high salt index can cause toxicity in sensitive crops	Watanabe *et al.* (2017)
Calcium Nitrate	Can lead to precipitation issues in high-calcium waters	Carina and Silva (2017)
Triphosphate Fertilizers	High insoluble content leading to sedimentation	Ma *et al*. (2020)

Fertigation in Date Palms Research

The most common date palm fertigation systems include drip fertigation, micro-sprinkler systems, etc. Studies on split nitrogen applications for the same crops in a similar irrigation cycle showed increases of 20–30% in yields compared to conventional schemes (Mahgoub *et al*., 2017). All studies assessed multiple fertigation approaches for date palms, using combinations of methods and inputs to address salinity issues and increase productivity. Mazahrih *et al*. (2018) compared three fertilizer application methods: continuous fertigation via a hydraulic injector (Dezetron), manual surface broadcast application 3 times a year, and a conventional bypass tank system delivering annual NPK (20:20:20) rates per tree via a drip irrigation schedule. The effect of nano-fertilizer (IQ Combi at 0, 0.5 and 1 g L^{-1}) or Disper Osmotic fertilizer (0, 1 and 2 g L^{-1}) was compared on growth and yield of two date palm cultivars by three times application through irrigation water in time of pollination; four weeks later (after the first application); eight weeks later by using 60 liters/palm as described by Abd *et al*. (2020) and Altemimy *et al* (2019). As another method of ameliorating salinity impact, Alturki (2020) used deionized water and saline (50-200 mM $NaSO_4$)+$Ca(NO_3)_2$ (0-20mM) solutions to irrigate three-year-old date palms in a

20-week experiment. Finally, Alnajjar *et al*. (2020) found that salinity was mitigated by adding the industrial isomer Neutra-Sol-335 at 1.5 L per 200 L of water to the irrigation tank throughout the month (see Table 5).

Table 5. Effect of fertigation of mineral nutrients on date palm

Nutrients	Concentrations	Treatment date	Cultivar	Details	References
NPK (20:20:20)	(1 kg of N, 0.5 kg P, and 1.5 kg K per tree	1st December	Madjool, Sacchari, Sggaa, and Kheyarah	increases in yield and fruit quality	Mazahrih *et al*. (2018)
nano-fertilizer (IQ Combi)	0, 0.5, and 1 g L^{-1}	1st March	Khastawi and Zahdi	Increased percentage of hold fruits, increase in fruit flesh weight, length, and weight of fruits	Altemimy *et al*. (2019)
bio-nutritious Disper Osmotic GS	0, 1, and 2 g L^{-1}	1st March	Khastawi and Zahdi	Increased percentage of hold fruits, increase in fruit flesh weight, length, and weight of fruits	Altemimy *et al*. (2019)
nano-fertilizer (IQ Combi)	0, 0.5, and 1 g L^{-1}	1st March	Khastawi and Zahdi	Increased leaf content of N, Pb, K, and Ca, decreased Na and Cl	Abd *et al*. (2020)
bio-nutritious Disper Osmotic GS	0, 1, and 2 g L^{-1}	1st March	Khastawi and Zahdi	Increased leaf content of N, Pb, K, and Ca, decreased Na and Cl	Abd *et al*. (2020)
Neutra-sol-335 industrial salinity enhancer	1.5 L per 200 L of water	Monthly for a year with irrigation water	Chipchap	Increasing offshoot height, trunk diameter, and root spread	Alnajjar *et al*. (2020)
NaCl	50, 100, 150 and 200 (mM)	1st April	Offshoots not known	Enhanced chlorophyll content and reduced the accumulation of Na and Cl in plant parts.	Alturki, (2021)
$Ca(NO_3)_2$	**0, 5, 10 and 20 mM**				

Challenges of Fertigation Applications

Modern fertilization practices for date palms, relying exclusively on chemical fertilizers, pose a significant challenge to the crop's productivity because of the complexity and interplay among numerous factors in the fertilization system. Fertilizer contamination is already one of the most pressing environmental and public health challenges we face. This contamination manifests in various ways, including nutrient leaching from soil into adjacent aquatic ecosystems, leading to water degradation, eutrophication, and oxygen-consuming algal blooms that kill aquatic organisms. This negative impact can be mitigated by maintaining a balance between the quantity of nutrients applied to the plant and their actual availability for absorption. One more major issue is over‑fertilization and its adverse effects. Excessive fertilizer applications—beyond what the crop requires—can elevate certain nutrients to toxic concentrations, harm plant health, and create soil chemical imbalances. Over‑fertilization weakens date palms, reduces their physiological efficiency, and increases production costs without agronomic benefits. Therefore, more stage‑specific fertigation practices must be developed, based on continuous soil analysis and real‑time monitoring of tree nutrient demand. The goal is to supply nutrients precisely in line with crop uptake curves—meeting, but not exceeding, the palms' nutritional requirements (i.e., avoiding both deficiency and toxicity). Furthermore, the soil of many date palm farms is deficient in various essential nutrients, either due to long‑term depletion or improper fertilizer application methods. Deficiencies of iron, magnesium, and potassium may limit palm growth and reduce fruit quality. A balance between nutrient needs and availability is a prerequisite for sustaining date palm cultivation, and providing adequate fertilization protocols requires updated knowledge among farmers. As is clear, there is a need to work together across all stakeholder groups — public and private sectors — to create a joint initiative for the sustainable production of palm resources, so that forests are protected against conversion.

Recommendations

To advance fertigation research and extension for date palms, researchers and agricultural extension services should prioritize developing cultivar‑specific nutrient uptake curves that define the dynamic demands for nitrogen, phosphorus, potassium, and magnesium across key phenological stages—pollination, fruit set, kimri, rutab, and tamar. Long‑term field trials are needed to validate the anti‑clogging efficacy of manganese ions (Mn^{2+}) under real irrigation conditions, particularly in high‑carbonate waters, while also quantifying environmental trade‑offs such as nitrous oxide emissions and overall life cycle impacts. Additionally, integrated protocols for the use of saline or brackish water in fertigation—including appropriate fertilizer blends and leaching fractions—must be developed to support date palm cultivation in arid regions. For farmers and orchard managers, the effective adoption of fertigation hinges on real‑time monitoring tools. Installing soil moisture and electrical conductivity (EC) sensors enables dynamic scheduling that prevents both over‑irrigation (which leaches nutrients) and under‑irrigation (which concentrates salts). Split applications of nitrogen and potassium—divided into 4 to 6 weekly or bi‑weekly doses during active growth—should replace single annual applications to match palm uptake and reduce leaching. To prevent emitter clogging, acidifying agents (e.g., phosphoric or nitric acid) should be injected to maintain a drip line pH between 6.0 and 7.0, especially when water has high bicarbonate or calcium content. Proper tank mixing is essential: avoid combining calcium nitrate with sulfates or phosphates in concentrated stock solutions, and follow sequential injection protocols. Regular system maintenance—flushing drip lines, cleaning filters, and periodic chlorination—must be performed routinely.

Conclusion

Now, one of the biggest advancements in managing date palm nutrition is fertigation. The consequences of irrigation and fertilizer techniques include better nutrient management, enhanced crop performance, and reduced environmental impact. Storylines for the use of sustainable agronomic practices exemplified by fertigation methods for cultivated date palms in a world underpinned by resource stress and a food boom.

References

Abd, A. M., Altemimy, I. H. H., and Altemimy, H. M. A. (2020). Evaluation of the effect of nano-fertilization and disper osmotic in treating the salinity of irrigation water on the chemical and mineral properties of date palm (*Phoenix dactylifera* L.). *Basrah Journal of Agricultural Sciences*, 33(1): 68–88. https://doi.org/10.37077/25200860.2020.33.1.06

Adamo, T., Caivano, D., Colizzi, L., Dimauro, G., and Guerriero, E. (2025). Optimization of irrigation and fertigation in smart agriculture: An IoT-based micro-services framework. *Smart Agricultural Technology*, 11: 100885. https://doi.org/10.1016/j.atech.2025.100885

Ahmed, N., Zhang, B., Chachar, Z., Li, J., Xiao, G., Wang, Q., Hayat, F., Deng, L., Narejo, M.-N., Bozdar, B., and Tu, P. (2024). Micronutrients and their effects on Horticultural crop quality, productivity and sustainability. *Scientia Horticulturae*, 323: 112512. https://doi.org/10.1016/j.scienta.2023.112512

Aisham, B., and Rahim, A. (2019). Design of reservoir tanks modelling to mix several types of fertilizer for fertigation planting system : part a. *IOP Conf. Series: Journal of Physics: Conf. Series* 1150: 012024. https://doi.org/10.1088/1742-6596/1150/1/012024

Alhamd, A. D. (2024). Impact of irrigation and mulching method on soil properties and date palm Phoenix dactylifera L. productivity. Basrah Journal of Date Palm Research, 23(2), 138–152.

Al-Nawaiseh, M. B. (2025). The Effect of Drip vs Hydroponic Irrigation Systems on Water Saving in Dry Regions. *International Journal of Agriculture and Biosciences*, 14(6): 1151–1159.

Ali, N. E.-D. S. (2012). *Fertilizer Techniques and Their Uses*. University Press for Printing, Publishing, and Translation.University of Baghdad. Higher Education and Scientific Research. Iraq.208 pp.

Alnajjar, M. A. A. H., Al-Hamad, A. D. S., and Al-Masaudi, A. J. O. (2020). The salinity treatment by neutra-sol and effect of organic fertilizer and irrigation water quality on protein pattern of date palm (*Phoenix dactylifera* L.) offshoots cv. chipchap. *Plant Cell Biotechnology and Molecular Biology*, 21(45–46): 52–62.

Altemimy, H. M. A., Altemimy, I. H. H., and Abed, A. M. (2019). Evaluation the efficacy of nano-fertilization and Disper osmotic in treating salinity of irrigation water in quality and productivity properties of date palm *Phoenix dactylifera* L. *Earth and Environmental Science*, 388: 012072. https://doi.org/10.1088/1755-1315/388/1/012072

Alturki, S. M. (2021). The potential use of ca (no3) 2 to improve salinity tolerance in date palm (*Phoenix dactylifera* L.). *Iraqi Journal of Agricultural Sciences*, 52(2): 445–453.

Ashrafi, M. R., Raj, M., Shamim, S., and Lal, K. (2020). Effect of fertigation on crop productivity and Nutrient use efficiency. *Journal of Pharmacognosy and Phytochemistry*, *9*(5): 2937–2942.

Brewer, M., KT, M., L, Z., and CD, S., D, K. (2018). Effect of Drip Irrigation and Nitrogen , Phosphorus and Potassium Application Rates on Tomato Biomass Accumulation , Nutrient Content , Yield , and Soil Nutrient Status. *Journal of Horticulture*, 5: 227.

https://doi.org/10.4172/2376-0354.1000227

Buck, G. B., Castro, G. F. De, Mattiello, E. M., and Zotarelli, L. (2020). Applications of Gypsum and Ammonium Sulfate Change Soil Chemical Properties of a Salt-Affected Agricultural Soil. *Journal of Agricultural Science*, 12(7): 1–14. https://doi.org/10.5539/jas.v12n7p1

Cai, D., Shoukat, M. R., Zheng, Y., Tan, H., Sun, M., and Yan, H. (2023). Improving Wheat Grain Yield and Nitrogen Use Efficiency by Optimizing the Fertigation Frequency Using Center Pivot Irrigation System. In *Water*, 15, 10: p. 1932). https://doi.org/10.3390/w15101932

Carina, A. N. A., and Silva, P. D. A. (2017). Technical paper calcium nitrate concentrations in fertigation for 'terra' banana production. *Journal of the Brazilian Association of Agricultural Engineering*, 37(2): 385–393. https://doi.org/http://dx.doi.org/10.1590/1809-4430-Eng.Agric.v37n2p385-393/2017 TORQUATO

Çetin, Ö., and Akalp, E. (2019). Efficient Use of Water and Fertilizers in Irrigated Agriculture: Drip Irrigation and Fertigation. Acta Horticulturae et Regiotecturae, 22(2), 97–102. https://doi.org/10.2478/ahr-2019-0019

Chtouki, M., Naciri, R., and Oukarroum, A. (2024). A review on phosphorus drip fertigation in the Mediterranean region: Fundamentals, current situation, challenges, and perspectives. *Heliyon*, 10(3): e25543. https://doi.org/10.1016/j.heliyon.2024.e25543

Dehghanisanij, H., Mirlatifi, S. M., Emami, S., Rajabzadeh, T. (2025). Reducing the clogging of emitters in drip irrigation systems using acid washing and ultrasonic technology. *Scientific Reports*, 15(1): 12499. https://doi.org/10.1038/s41598-025-95915-w

Dhaouadi, L., and Haj-Amor, Z. (2025). Irrigation water requirements of date palms in the Arab region: influencing factors, climate change effect, and sustainable irrigation practices. *Euro-Mediterranean Journal for Environmental Integration*, 11(1): 52. https://doi.org/10.1007/s41207-025-00959-z

El-Salhy, A. M., Hemdan, H., Khalil, O. A., and Doaa, M. F. A. (2024). Effect of foliar spray of urea and potassium citrate on fruiting of Barhee date palm. *Aswan University Journal of Science and Technology*, 4(2): 140–150. https://doi.org/https://journals.aswu.edu.eg/stjourna

Elsayd, I. A. E.-R., El-Merghany, S., Zaen and El – Dean, E. M. A. (2018). Influence of Potassium Fertilization on Barhee Date Palms Growth, Yield and Fruit Quality Under Heat Stress Conditions. *Journal of Plant Production*, 9(1): 73–80.

https://doi.org/10.21608/jpp.2018.35258

Farag, A. A., El-Aziz, M. A. A., and El-Husseiny, A. M. (2025). Effects of irrigation systems and water management strategies on soil chemical properties and citrus tree productivity in clayey soils. Scientific Reports, 15(1), 33324. https://doi.org/10.1038/s41598-025-19575-6

Fasal, H. A., AbdulWahid, A. H., and Authafa, Q. J. (2014). Effect of spray phosphorus and proline on some physical and chemical characteristics and production for date palm Phoenix dactylifera L. Shuker cultivar Hassan. *Basra Jurnal for Date Palm Research*, 13(1–2): 2–8.

Ghazzawy, H. S., Alqahtani, N., Munir, M., Alghanim, N. S., and Mohammed, M. (2023). Combined Impact of Irrigation, Potassium Fertilizer, and Thinning Treatments on Yield, Skin Separation, and Physicochemical Properties of Date Palm Fruits. *Plants (Basel, Switzerland)*, 12(5). https://doi.org/10.3390/plants12051003

Ghosh, S., Pradhan, P., and Behera, P. (2025). Fertigation. In S. P. Shinde (Ed.), *Natural Resource Management in Agriculture : A Modern-Day Necessity* (p. 518).

Görlach, B. M., and Mühling, K. H. (2021). Phosphate foliar application increases biomass and P concentration in P deficient maize. *Journal of Plant Nutrition and Soil Science*, *184*(3), 360–370. https://doi.org/https://doi.org/10.1002/jpln.202000460

Jasim, A. M., Abbas, M. F., and Shareef, H. J. (2016). Calcium application mitigates salt stress in Date Palm (*Phoenix dactylifera* L.) offshoots cultivars of Berhi and Sayer. *Acta Agriculturae Slovenica*, 107(1): 103–112. https://doi.org/10.14720/aas.2016.107.1.11

Kassem, H. A. (2012). The response of date palm to calcareous soil fertilisation. In *Journal of Soil Science and Plant Nutrition* 12 (1): 45–58). https://doi.org/10.4067/S0718-95162012000100005

Kaur, T., Sharma, P. K., Brar, A. S., Singh, S., and Singh, S. (2025). Precision irrigation and fertilization strategies for sustainable cotton-wheat systems in water-scarce regions. *Agricultural Water Management*, 317: 109669. https://doi.org/https://doi.org/10.1016/j.agwat.2025.109669

Ma, C., Xiao, Y., Puig-Bargués, J., Shukla, M. K., Tang, X., Hou, P., and Li, Y. (2020). Using phosphate fertilizer to reduce emitter clogging of drip fertigation systems with high salinity water. *Journal of Environmental Management*, 263: 110366. https://doi.org/https://doi.org/10.1016/j.jenvman.2020.110366

Mahgoub, N. A., Mohamed, A. I., Sayed, E., Sikhary, M. El, and Ali, O. M. (2017). Roots and Nutrient Distribution under Drip Irrigation and Yield of Faba Bean and Onion. Open

Journal of Soil Science, 7, 52–67. https://doi.org/10.4236/ojss.2017.72004

Mazahrih, N. T., Al Sayari, A. S., Al Shamsi, S. A., and Salah, M. B. (2018). Drip Fertigation Technology for Enhancing Date Palm Productivity and Fruit Quality. *Journal of Agricultural Science*, 10(11): 380. https://doi.org/10.5539/jas.v10n11p380

Muhammad, T., Zhou, B., Liu, Z., Chen, X., and Li, Y. (2021). Effects of phosphorus-fertigation on emitter clogging in drip irrigation system with saline water. *Agricultural Water Management*, 243: 106392. https://doi.org/https://doi.org/10.1016/j.agwat.2020.106392

Murad, H. J., and Al-Dulaimy, A. F. Z. (2021). Response of Date Palms Cv . Zahdi to Foliar Spray with Urea and Seaweed Extract. *Earth and Environmental Science*, 761: 012052. https://doi.org/10.1088/1755-1315/761/1/012052

Pibars, S. K., Gaballah, M. S., Mansour, H. A., and Khalil, S. E. (2022). Management of fertigation and its effects on irrigation systems performance and crop yield. *International Journal of Health Sciences*, 6(S2 SE): 1634–1659. https://doi.org/10.53730/ijhs.v6nS2.5420

Salama, A. S. M., El-Sayed, M., and Abdel-Hameed, A. A. (2014). Effect of Magnesium Fertilizer Sources and Rates on Yield and Fruit Quality of Date. *Research Journal of Agriculture and Biological Sciences*, 10(2): 118–125.

Sarma, H. H., Paul, A., Kakoti, M., and Talukdar, N. (2023). Fertigation: A Modern Approach for Enhancing Nutrient use Efficiency. In *Frontiers in Agricultural Sustainability* (pp. 113–126). Integrated Publications TM.

Shareef, H. J., Abbas, M. F., and Jasim, A. M. (2022). Response of date palm offshoots (*Phoenix dactylifera* L .) Sayer cultivar to the foliar spray of salicylic acid and citric acid under salinity conditions. *Folia Oecologica*, 49(2): 130–136. https://doi.org/10.2478/foecol-2022-0015

Shareef, H. J., and ALarab, E. H. (2025). Antioxidant compounds enhanced the anatomical characteristics of Date Palm (*Phoenix dactylifera* L.) offshoot leaves under salinity stress. *Basrah Journal Of Date Palm Research*, 24(2): 92–113. https://palm.uobasrah.edu.iq/index.php/paml/article/view/80

Singh, B., and Craswell, E. (2021). Fertilizers and nitrate pollution of surface and ground water : an increasingly pervasive global problem. *SN Applied Sciences*, 3(4): 1–24. https://doi.org/10.1007/s42452-021-04521-8

Sneha, R., Jegadeeswari, V., Vijayalatha, K. R., Kaleeswari, R. K., Nithila, S., and

Kalaivani, J. (2025). Effect of Fertigation on Soil Nutrients, Microbial Activity, Plant and Fruit(s) Growth Parameters Grown Under Tropical Environments: A Discussion. *Communications in Soil Science and Plant Analysis*, 00(00): 1–29. https://doi.org/10.1080/00103624.2025.2522190

Sood, T., Kapoor, S., Kaur, J., Hussain, N., and Sood, S. (2025). Fertigation: A Paradigm Shift in Nutrient Delivery for Sustainable Agriculture BT - Agricultural Nutrient Pollution and Climate Change: Challenges and Opportunities. In N. Hussain, C.-Y. Hung, & L. Wang (Eds.), *Agricultural Nutrient Pollution and Climate Change* (pp. 135–164). Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-80912-5_5

Suhim, A. A., Abbas, K. F., and Al-Jabary, K. M. A. (2017). Oxidative responses and genetic stability of date palm Phoenix dactylifera L. Barhi cv. under salinity stress. *Journal of Biology*, 7(8): 70–80.

Sun, X., Li, Y., Heinen, M., Ritzema, H., Hellegers, P., and van Dam, J. (2023). Fertigation Strategies to Improve Water and Nitrogen Use Efficiency in Surface Irrigation System in the North China Plain. In Agriculture (Vol. 13, Issue 1, p. 17). https://doi.org/10.3390/agriculture13010017

Watanabe, K., Tominaga, J., Takaragawa, H., and Ueno, M. (2017). Effects of Different Kinds of Potassium and Chloride Salts on Sugarcane Quality and Photosynthesis. *Sugar Tech*, 19(4): 378–385. https://doi.org/10.1007/s12355-016-0486-2

Xing, Y., and Wang, X. (2024). Precise application of water and fertilizer to crops : challenges and opportunities. *Front Plant Sci*, 15: 1444560. https://doi.org/10.3389/fpls.2024.1444560

Xing, Y., Xie, Y., and Wang, X. (2025). Enhancing soil health through balanced fertilization: a pathway to sustainable agriculture and food security. *Frontiers in Microbiology*, 16: 1536524. https://doi.org/10.3389/fmicb.2025.1536524

Xu, T., Bao, S., Yu, Q., and Gao, Y. (2025). Solving Phosphorus Fertilization-Related Drip Irrigation Emitter Clogging by Adding Mn^{2+}. *Agronomy*, 15(1): 127. https://doi.org/10.3390/agronomy15010127

دور التسميد المائي في تحسين كفاءة استخدام المياه والمغذيات في زراعة وإنتاج نخيل التمر

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الخلاصة

برز التسميد المائي، وهو تطبيق الأسمدة مع الماء عبر نظام الري، كنهج فعال لتعزيز كفاءة استخدام المياه والمغذيات في النخيل. تسلط هذه المراجعة الضوء على التقدم الحالي في تطبيق تقنية التسميد المائي لتحسين نمو النخيل، وإنتاجيته، وجودة ثماره، واستدامته في البيئات الجافة وشبه الجافة. وتغطي المراجعة أنواعًا مختلفة من الأسمدة القابلة للذوبان في الماء، وتأثيرها على توافر المغذيات في التربة المحيطة بالجذور، وتقنيات التسميد المائي المختلفة. إضافةً إلى ذلك، تُبرز المراجعة أيضًا دور ترشيد استهلاك المياه وحماية البيئة من خلال تقليل فقدان المغذيات وتحسين إدارة الأسمدة عبر التسميد المائي. كما تُستعرض القيود المتعلقة بالتكنولوجيا، مثل جودة المياه، وانسداد المنقطات، والإدارة. وبشكل عام، تشير نتائج هذه الدراسة إلى أن التسميد المائي يمكن أن يكون تقنية واعدة لإنتاج النخيل المستدام عند دمجه مع ممارسات الري الجيدة وإدارة المغذيات.

.الكلمات المفتاحية: التسميد المائي، تغذية نخيل التمر، الري بالتنقيط، الأسمدة القابلة للذوبان في الماء، كفاءة استخدام العناصر الغذائية.