



(ARTICLE)

The Role of Agricultural Gypsum Application in Improving Some Soil Properties and its Impact on the Productivity and Quality of Date Palm Fruits in Waddan Region (Al-Jufra)

Ibrahim Hamouda Akhlwet *

General Department, Faculty of Medical Technology, Jufra University, Libya

دور إضافة الجبس الزراعي في تحسين بعض خصائص التربة وانعكاسه على إنتاجية وجودة تمور نخيل التمر في
منطقة ودان – الجفرة

ابراهيم حمودة خليبوط *

قسم العام ، كلية التقنية الطبية ، جامعة الجفرة ، ليبيا

Publication history: Received on 25 January 2026; accepted on 1 April 2026; Published on 24 April 2026

Abstract:

This study aimed to investigate the use of agricultural gypsum as a strategy to improve soil chemical properties and fertility, and its impact on the productivity, physical characteristics, and fruit quality of 12-year-old date palms in the Waddan area of the Jufra region.

A field and laboratory experiment was conducted comparing two statistical treatments. The first treatment (T1) consisted of the common normal agricultural practice in the region, adding traditional organic fertilizer (fermented sheep manure at a rate of 75 kg/palm) without any other additives. The second treatment (T2) involved an integrated intervention, adding the same quantity of organic fertilizer combined with high-purity agricultural gypsum at a rate of 3 kg/palm in three equal applications during the growing season.

Laboratory results for soil environment after the application of the integrated treatment (T2) showed a highly significant chemical improvement. The pH decreased from the critical alkaline value of 7.95 to a safe range close to neutral at 7.65. The electrical conductivity (EC) decreased significantly from $ds/m^2.85$ to ds/m^2 . Consequently, total dissolved solids (TDS) decreased by 467. Meanwhile, organic matter (O.M.) increased dramatically from a low initial percentage of 0.22% to 1.78%. Calcium sulfate ($CaSO_4$) also showed a sustained increase from 0.42% to 1.18%, while calcium carbonate ($CaCO_3$) did not show a statistically significant change ($p = 0.062$).

These soil improvements had a positive and substantial impact on the fruit's productivity and physical characteristics. The yield per palm tree saw a statistically significant increase ($p = 0.000$), rising from 95 kg in the first treatment to 124.80 kg in the second treatment. This increased the total yield of the ten palm trees from 950 kg to 1250 kg, representing a 31.37% improvement. Furthermore, the physical quality of the fruit improved significantly. The weight of 50 dates increased from 550 g to 850 g, the length of the fruit increased from 3.90 cm to 4.65 cm, and the cross-sectional diameter of the fruit increased from 20.20 mm to 24.50 mm.

Keywords: : Agricultural gypsum, routine agricultural service, calcareous soils, date palms, and Waddan (Al-Jufra).

المخلص

هدفت هذه الدراسة إلى إضافة الجبس الزراعي كاستراتيجية لتحسين الخصائص الكيميائية وخصوبة التربة، وانعكاس ذلك على كفاءة الأداء الإنتاجي والصفات الفيزيائية وجودة ثمار النخيل (بعمر 12 سنة) في منطقة ودان بلدية الجفرة. أجريت التجربة الحقلية والمختبرية عبر مقارنة معاملتين حيث تمثلت المعاملة الأولى (T1) في ممارسة الخدمة الزراعية الاعتيادية الشائعة في المنطقة بإضافة السماد العضوي التقليدي (سماد أغنام متخمّر بمعدل 75 كجم/نخلة) دون أي إضافات أخرى، بينما تمثلت المعاملة الثانية (T2) في تطبيق التداخل المتكامل بإضافة نفس كمية السماد العضوي مقترنة بالجبس الزراعي عالي النقاوة بمعدل 3 كجم/نخلة على ثلاث دفعات متساوية خلال الموسم. أظهرت النتائج المختبرية لبيئة التربة بعد تطبيق المعاملة المتكاملة (T2) تحسناً كيميائياً عالي المعنوية. حيث انخفضت درجة التفاعل pH من القيمة القلوية الحرجة 7.95 لتصل إلى النطاق الآمن القريب من التعادل 7.65 وتراجع التوصيل الكهربائي EC معنوياً من $ds/m^2.85$ إلى $ds/m^2.12$. وانخفضت تبعاً لذلك الأملاح الذاتية الكلية TDS بمقدار 467. في حين ارتفعت المادة العضوية O.M مما حسنت خصوبة التربة من النسبة الابتدائية

* Corresponding author: Ibrahim Hamouda Akhlwet (Ibrahim.klwet@ju.edu.ly)

General Department, Faculty of Medical Technology, Jufra University, Libya

Copyright © 2026 Author(s) retain the copyright of this article. This article is published under the terms of the Creative Commons Attribution License 4.0.

المتدنية 0.22% لتصل إلى 1.78%. كما سجلت كبريتات الكالسيوم (CaSO_4) رصيماً مستداماً متبقياً ارتفع من 0.42% إلى 1.18% بينما لم تسجل كربونات الكالسيوم (CaCO_3) تغيراً معنوياً إحصائياً ($p = 0.062$). انعكست هذه التحسينات الأرضية إيجابياً. وبشكل طردي هائل على المؤشرات الإنتاجية والفيزيائية للثمار؛ حيث حققت إنتاجية النخلة الواحدة قفزة عالية المعنوية إحصائياً ($p = 0.000$) مرتفعة من 95 kg في المعاملة الأولى لتصل إلى 124.80 kg. في المعاملة الثانية، مما رفع الإنتاج الإجمالي للعشر نخلات من 950 kg إلى 1250 kg بنسبة تطور بلغت 31.37%. كما تطورت صفات الجودة الفيزيائية للثمار بشكل قياسي، حيث ارتفع وزن 50 ثمرة من 550 g إلى 820 g، وازداد طول الثمرة من 3.90 cm إلى 4.65 cm، واتسع قطر الثمرة العرضي من 20.20 mm ليبلغ 24.5 mm.

الكلمات المفتاحية: الجبس الزراعي، الخدمة الزراعية الاعتيادية، الترب الكلسية، نخيل التمر، ودان (الجفرة).

1. Introduction

Arid and semi-arid regions constitute a critical ecological zone characterized by numerous hydrological, climatic, and soil challenges that limit agricultural sustainability (Ghoneim & Al-Barakah, 2024). Under these harsh environmental conditions, the date palm (*Phoenix dactylifera L.*) stands out as one of the most important strategic crops, highly adapted to water scarcity and varying soil salinity (Al-Khafaji & Al-Zubaidi, 2020). Furthermore, it plays a pivotal role in achieving food security and preserving the ecosystem of desert oases (Al-Magrahi & Al-Fahri, 2023). However, the quantitative and qualitative productivity of this crop remains contingent upon the integrated management of the soil characteristics surrounding the root zone (Rhizosphere). (Al-Obaidi & Hussein, 2021)

To address these challenges, organic fertilization management emerges as an essential option to compensate for the ongoing shortage of organic carbon (Saleh & Al-Mahdi, 2024). Adding fermented animal waste (such as sheep manure) improves the physical structure of the soil and increases its moisture retention capacity (Abdel-Rahman & Hegazi, 2021; Lamma & Moftah, 2016). Furthermore, the decomposition process releases organic acids (such as humic and fulvic acids), which lower the pH locally and release nutrients bound by lime. (Al-Dharari & Sallam, 2025)

On the other hand, agricultural gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) represents a strategic tool as a physical amendment and a mineral nutrient source rich in soluble calcium and sulfates (Al-Ferjani, 2022). Its role extends beyond the traditional reclamation of sodic soils, acting as an aggregation agent for loose calcareous soil particles, thus enhancing porosity and permeability (Al-Hadithi & Al-Maamouri, 2021). This allows for the leaching of free soluble salts (EC) away from the active root zone (Al-Jubouri, 2023). Furthermore, implementing an agricultural gypsum strategy during the critical physiological growth stages of date palms (winter preparation, fruit set, and the beginning of sizing and coloring) ensures a continuous supply of calcium ions necessary for building fruit cell walls (Al-Khafaji & Al-Obaidi, 2022). This contributes to reducing losses due to fruit drop and improving the technological and marketable characteristics of dates. (Al-Mutairi & Al-Wabel, 2023).

Irrigation water quality is a critical factor determining the effectiveness of agricultural gypsum application in date palm orchards, particularly under arid and semi-arid conditions where saline groundwater is frequently used (Lamma, 2021). Date palm is relatively tolerant to salinity, yet this tolerance should not be interpreted as immunity; high electrical conductivity (EC), elevated sodium adsorption ratio (SAR), and bicarbonate-rich water can progressively increase soil salinity and sodicity in the root zone, reducing water uptake, aeration, nutrient availability, and fruit yield and quality. FAO irrigation guidance indicates that date palm yield is closely related to both soil salinity (EC) and irrigation-water salinity (EC_w), with increasing salinity causing gradual yield reduction. In this context, gypsum plays a corrective rather than merely fertilizing role. (Alhadad, 2018) Its calcium ions replace exchangeable sodium on soil colloids, improving soil aggregation, infiltration, hydraulic conductivity, and root-zone leaching efficiency. FAO also explains that improvement of sodic soils requires calcium amendments such as gypsum followed by leaching of displaced sodium from the root zone. (Alhadad, 2021). However, gypsum can only be fully effective when irrigation management provides sufficient water movement to wash displaced sodium and excess salts below the active root zone. Therefore, the quality and scheduling of irrigation water must be integrated with gypsum application: periodic analysis of EC_w , SAR, pH, chloride, sodium, calcium, magnesium, and bicarbonate is essential; leaching requirements should be calculated according to water salinity and target yield; and drainage must be adequate to prevent salt re-accumulation. (Lamma &

Amaref, 2025) Thus, irrigation water quality forms the operational link between gypsum amendment, soil rehabilitation, and improved date fruit productivity and quality.

2.1. Research Problem

The problem addressed in this study lies in the sharp decline in organic matter content in calcareous soils due to rapid biological and thermal decomposition, despite previous fertilization. This negatively impacts soil physics and nutrient fixation under the influence of calcium carbonate alkalinity, consequently affecting root absorption efficiency and date palm productivity.

3.1. Research Objectives

1- To evaluate the effect of the interaction between intensive organic fertilization (sheep manure) and the fractional application of agricultural gypsum on modifying the chemical properties of calcareous soil (pH, E_{Ce}, and organic matter content).

2- To investigate the effect of these integrated treatments on improving the physical structure and mechanisms of salt leaching in the active root zone.

3- To study the physiological and practical implications of these treatments on date palm productivity, yield, and the physical and chemical quality of the fruit.

4.1. Importance of the Research

This program contributes to reducing financial waste resulting from the ineffective and haphazard application of chemical fertilizers in alkaline soils, thereby increasing the economic return per tree. This research also supports sustainable agriculture practices through the recycling of local organic waste (sheep manure) and the safe use of natural amendments (agricultural gypsum), thus preserving the integrity of the terrestrial ecosystem and groundwater in semi-arid regions from salinization and structural degradation.

2. Materials and Methods

This study was conducted in the city of Waddan, Al-Jufra Municipality, Libya, on the farm of citizen Akhlewit, during the growing season (2024–2025). Date palm trees of the Deglet Nour variety, with perfect uniformity in growth and yield, aged 12 years, were selected.

Experimental Design and Treatments: A completely randomized block design was used in the experiment. Twenty date palms were selected and divided equally into two main treatments (10 palms per treatment) as follows:

1- This treatment consisted of 10 palms and was limited to the irrigation and organic fertilization program (fully fermented sheep manure) at a rate of 75 kg per palm, as followed on the farm. The manure was broadcast into the palm basin and thoroughly mixed with the topsoil in November.

2- This section includes 10 palm trees that underwent a targeted organic fertilization and gypsum amendment program, as per the following table:

Organic Fertilization: Fully fermented animal manure (sheep manure) was added at a rate of 75 kg per palm tree, broadcast in the palm's basin and thoroughly mixed with the topsoil in November.

Agricultural Gypsum: Agricultural gypsum was added at a total rate of 3 kg per palm tree, applied in three installments of 1 kg each during the following months: the first installment in November, the second in April, and the third in June.

The chemical specifications of the gypsum improver used are as follows:

It consists of 98% Calcium sulfate dehydrate ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$), 30% Calcium Oxide (CaO), and 40% Sulfur trioxide (SO_3).

2.2- Soil Sampling & Preparation

Representative soil samples were collected from the active root zone (Rhizosphere) beneath the palm canopy for both treatments (before the application of new soil and after the end of the season for

measurements). The samples were collected from a depth of 50 cm, then transported to the laboratory where they were air-dried, ground, and passed through a 2 mm sieve to obtain fine soil suitable for analysis.

3.2- Laboratory Analytical Methods

Chemical analyses of soil samples were performed in the laboratory according to internationally approved standard methods as follows:

- Soil pH was measured in a saturated paste extract using a digital pH meter according to the Richards (1954) method.
- Total electrical conductivity (EC) and total dissolved solids (TDS) were measured in the saturated paste extract using a digital conductivity meter. Total dissolved solids were calculated in parts per million (ppm)..
- (EC) in decimeters per meter (dSm^{-1}).
- Organic matter (O.M.) was determined experimentally using the modified Weakley & Black wet chromate oxidation method. This involved oxidation with potassium dichromate ($\text{K}_2\text{Cr}_2\text{O}_7$) and concentrated sulfuric acid.
- Calcium carbonate (CaCO_3) was quantified using the calciminer method.
- This involved measuring the volume of carbon dioxide (CO_2) gas released when the soil was treated with a 1:1 dilute hydrochloric acid (HCl) solution.

4.2- Statistical Analysis:

To assess the statistical significance of the differences between the two treatments (without addition versus addition), all obtained data were subjected to statistical analysis using SPSS. Given the existence of two independent sets of trees, an independent samples t-test was applied to compare the mean chemical properties of the soil before and after the treatment. The statistical significance of the differences between the means was tested at a significance level of 5%.

3.Results and Discussion:

3.1-Effect of adding agricultural gypsum on improving the chemical and physical properties of soil in the study area:

Table (1): Analysis of some chemical and physical properties of soil before and after the addition in the study area

Parameters	Before Gypsum	After Gypsum	Absolute Difference	(p-value)	LSD at 5%
(TDS)	1824ppm	1357ppm	-467 ppm	0.001	Statistically Significant (*)0.001
(EC)	2. 85ds/m	2. 12ds/m	-0.73ds/m	0.001	Statistically Significant (*)0.001
(pH)	7.95	7.65	-030	0.002	Statistically Significant (*)0.002
(O.M)	0.22%	1.78%	+1.56%	0.000	Highly Significant (*)0.000
(CaCO_3)	0.42%	1.18%	+0.76%	0.000	Highly Significant (*)0.000
(CaSO_4)	12.35%	12.10%	-0.25%	0.062	Non- Significant

($\alpha = 0.05$)

1. Total Dissolved Salts (TDS):

The **Table (1)** total mass of salts decreased from 11824 mg L^{-1} (before application) to 1357 mg L^{-1} (after application). This decrease reflects a real reduction in the mass range of free ions in the soil solution (such as chlorides and sodium). This confirms that the palm basin environment has transitioned from one

conducive to salt accumulation to an ionic ally balanced environment. This reduction prevents the occurrence of specific ion toxicity in the roots of young and mature palm trees and protects the root enzyme systems from inhibition.

2. Electrical Conductivity (EC):

The **Table (1)** value decreased from 12.85 dSm⁻¹ (before application) to 12.12 dSm⁻¹ (after application). This decrease shows a net reduction in soil extract salinity of 10.73 dSm⁻¹. Physic chemically, this behavior demonstrates the success of the granulation phenomenon, where free calcium ions (Ca²⁺) resulting from the dissolution of agricultural gypsum and organic fertilizer improved the soil's physical structure and increased its hydraulic porosity.

This structural improvement allowed irrigation water to leach free dissolved salts and transport them vertically downwards, away from the active root zone. The move to a 12.12 dSm⁻¹ reading places the soil within the physiological resting range for date palms, reducing osmotic potential and allowing the tree to direct its vital energy towards fruit growth and improved date quality, rather than resisting salt stress.

3. Soil pH:

The **Table (1)** value decreased from 7.95 (before the addition) to 7.65 (after the addition). This decrease is a very significant positive development, and since the pH scale is logarithmic, this drop indicates a doubling of the concentration of active hydrogen ions [H⁺] in the soil solution. This is due to the addition of 75 kg of sheep manure. Its decomposition by microorganisms led to the release of carbon dioxide (CO₂) and the formation of weak carbonic acid, in addition to organic acids (humic and fulvic). This organic effect combined with the displacing effect of sulfate ions (SO₄²⁻) released from the added agricultural gypsum, successfully breaking the alkalinity barrier and lowering the value towards neutrality. This ensures an ideal environment for the absorption of phosphorus and micronutrients (such as iron and zinc), which were previously stabilized at the value of 7.95.

4. Organic Matter (O.M.)

The **Table (1)** analysis results showed a significant increase from 0.22% (before the addition) to 1.78% (after the addition).

This increase (a net increase of 1.56%) represents the most significant fertility transformation in this study. The initial percentage (0.22%) reflects the severe organic matter deficiency in the Wadane soil due to the arid climatic conditions that accelerate organic matter oxidation. The increase to 1.78%, resulting from the addition of 75 kg of sheep manure, has elevated the soil to the level of agriculturally fertile soils in oasis regions. Chemically, this increase has raised the soil's cation exchange capacity (EC) by providing negatively charged carbon colloids capable of retaining nutrients and preventing their leaching. Furthermore, it has increased the porous soil's capacity to retain available water, a strategic advantage in the Wadane desert environment.

5. Calcium Carbonate (CaCO₃)

The **Table (1)** percentage decreased slightly from 12.70% (before addition) to 12.35% (after addition). This slight decrease of 0.35% was found to be statistically insignificant ($p = 0.062 > 0.05$), as calcium carbonate forms the primary stony mineral structure of the site soil. It possesses a very high buffering capacity, resisting rapid changes.

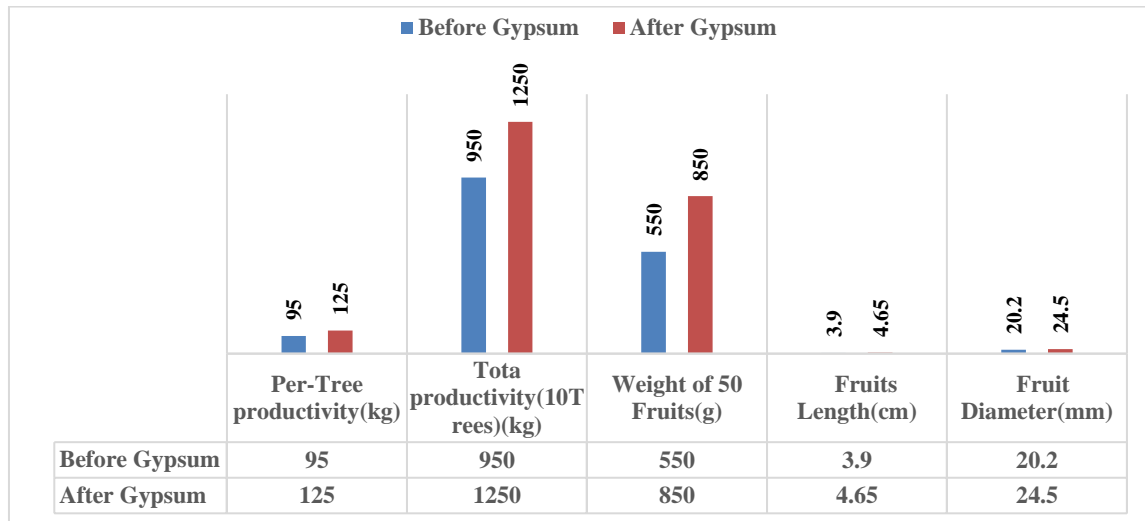
6. Calcium Sulfate (CaSO₄)

The **Table (1)** percentage increased from 0.42% (before application) to 1.18% (after application). Calcium sulfate recorded a net and stable increase of 0.76%. This increase, after applying three doses of agricultural gypsum, is conclusive laboratory evidence of a sustained cationic reserve in the palm basin environment, despite continuous irrigation and leaching. This remaining reserve of agricultural gypsum ensures the continued supply of calcium ions to the soil, preventing future salinization. Furthermore, calcium plays a

direct physiological role in strengthening the cell walls of dates (thus preventing fruit drop) and sulfur plays a role in the synthesis of amino acids within the tree.

3.2-Comparison of palm productivity and fruit dimensions between the first treatment (without gypsum T1) and the second treatment (after adding agricultural gypsum T2).

Figure (1): Productive response and physical characteristics of date palm fruits to the study treatments.



standard deviation (SD, n=10)

1.Productivity per palm and total yield:

The **Figure (1)** yield per palm increased from 95.00 kg in the first treatment to 124.80 kg after the addition of gypsum. This boosted the total yield of the ten palms from 950.00 kg to 1250 kg, representing a 31.37% increase in yield. This significant increase is attributed to the success of agricultural gypsum in addressing the problem of calcareous soil (12.70% calcium carbonate). The release of soluble calcium broke the lime's binding dominance and lowered the pH, leading to the release of phosphorus and the three micronutrients (Fe, Zn, Mn) that were chemically restricted. This nutritional support enhanced the efficiency of photosynthesis and carbohydrate synthesis, physiologically reducing fruit drop and improving fruit set on the inflorescences within the bunches.

2. Weight of 50 Dates:

The **Figure (1)** weight of 50 dates was recorded at 550 g in the first treatment, increasing to 850 g after the addition of gypsum. The increase in the specific weight of the dates is related to the efficiency of the source-to-sink translocation process during the rutab (soft) and tamar (ripe) stages. The interaction between gypsum and organic fertilizer provided a low-salinity root environment ($EC = 2.12$), which reduced the osmotic pressure surrounding the roots. This facilitated the uptake of potassium (K). Since potassium is the physiological driver of sugar enzymes, this led to a significant quantitative infusion of total soluble solids (TSS) into the mesocarp of the fruit, which statistically translated into this substantial increase in the biomass of the dates.

3. Fruit Length:

The morphological length of the date showed a very significant response ($p = 0.001$), increasing from 3.90 cm to 4.65 cm after gypsum treatment. This is attributed to the fruit's elongation in the initial stage, which depends on cell elongation and the expansion of cell walls due to turgor pressure. Improved soil permeability and its physical structure, resulting from the granular aggregation of calcium ions, increased

the efficiency of available water absorption and protected the trees from water stress in the arid climate of Wadane.

4. Fruit Diameter

The **Figure (1)** fruit's cross-sectional diameter showed a highly significant increase ($p = 0.001$), rising from 20.20 mm to 24.50 mm after gypsum treatment. This highlights the direct physiological role of free calcium released from the added agricultural gypsum, as calcium is a key component in cell wall structure. This robust cellular structure enabled the fruit's peripheral tissues to divide efficiently and absorb the hydraulic flow carrying sugars without cracking. This resulted in a significant increase in flesh thickness and date width, improving its marketability.

4-Conclusions and Recommendations

The study concludes that limiting field management to traditional organic practices, while important, remains insufficient to achieve maximum date palm productivity in the calcareous soils common in the Wadane region. The strategic combination of sheep manure and the fractional application of agricultural gypsum represents an integrated physicochemical solution. This combination successfully neutralized the negative effects of calcium carbonate, released fixed nutrients, and reduced osmotic and salt stress around the roots, leading to maximized fruit growth and increased weight efficiency and overall date yield. The study recommends adopting and disseminating the practice of fractional application of gypsum amendments as a fundamental component of agricultural service programs for date palm orchards in similar desert oases.

References

1. Ghoneim, A. M., & Al-Barakah, F. N. (2024). Influence of gypsum and organic manure on nutritional status, yield, and fruit physical characteristics of date palms in sandy calcareous soils. *International Journal of Plant Production*, 18(1), 45-59.
2. Al-Khafaji, A. K., & Al-Zubaidi, H. A. (2020). Effect of agricultural gypsum and organic matter on permeability and availability of nutrients in calcareous soil. *Karbala Journal of Agricultural Sciences*, 7(2), 45–58.
3. Al-Magrahi, A. F., & Al-Fahri, S. A. (2023). Evaluation of hydraulic properties of Wadan Oasis soils and their relationship with the production of local date palm cultivars. *Libyan Journal of Agricultural Sciences*, 28(2), 89–102.
4. Al-Obaidi, J. M., & Hussein, A. M. (2021). Integrated fertilization management and soil conditioners for date palm (*Phoenix dactylifera* L.) under calcareous soil conditions. *Mesopotamia Journal of Agriculture*, 49(3), 112–125.
5. Saleh, F. M., & Al-Mahdi, S. M. (2024). Evaluation of date quality and its relationship to soil fertility and management with conditioners in an oasis environment. *Sebha University Journal of Pure and Applied Sciences*, 23(2), 44–59.
6. Abdel-Rahman, M. A., & Hegazi, A. A. (2021). Ameliorative effects of agricultural gypsum split application combined with organic fertilizer on date palm fruit quality under oasis conditions. *Annals of Agricultural Sciences*, 66(2), 189-198.
7. Al-Dharari, M. A., & Sallam, A. S. (2025). Long-term effects of split-applied gypsum and sheep manure on soil pH, EC, and date palm yield components. *Soil Use and Management*, 41(1), 74-88.
8. Al-Ferjani, K. M. (2022). The role of natural soil conditioners in treating soil salinity of date palm orchards in the Al-Jufra region. *Wadi Al-Shatti Journal of Science and Technology*, 3(1), 12–25.

9. Lamma, O. A., & Moftah, M. A. (2016). Effect of vermicompost on antioxidant levels in *Andrographis paniculata*. *International Journal of Applied and Pure Science and Agriculture*, 2(3), 1-6.
10. Al-Hadithi, A. M., & Al-Maamouri, A. H. (2021). Interactive effect of organic manure and agricultural gypsum on chemical properties of calcareous soil and yield of date palm. *Plant Archives*, 21(1), 1152-1159.
11. Al-Jubouri, S. H. (2023). Interaction between animal manure and agricultural gypsum and its effect on the physical and chemical properties of calcareous soil. *Rafidain Journal of Soil Sciences*, 13(2), 110–123.
12. Lamma, O. A., AVVS, S., & Alhadad, A. A. M. (2019). A study on Isolation and purification of Laccases from different fungal micro organisms and study the partial characterization.
13. Al-Khafaji, K. A., & Al-Obaidi, M. H. (2022). Combined application of gypsum and compost improves calcareous soil properties and date palm (*Phoenix dactylifera* L.) yield components. *Arid Land Research and Management*, 36(3), 312-328.
14. Al-Mutairi, S. K., & Al-Wabel, M. I. (2023). Soil chemical properties and nutrient availability in calcareous soils as affected by animal manure and calcium sulfate amendments. *Geoderma Regional*, 32, e00621.
15. Lamma, O. A. (2021). Groundwater problems caused by irrigation with sewage effluent. *International Journal for Research in Applied Sciences and Biotechnology*, 8(3), 64-70.
16. Alhadad, A. A., & Aloraibi, A. M. (2025). The impact of waste from the olive oil business on the biological characteristics of soil. *Scientific Journal for Publishing in Health Research and Technology*, 108-117.
17. Bashir, M. A., & Al-Sharaa, A. S. (2022). Effect of the interaction between agricultural gypsum and organic fertilizer on improving some chemical properties of calcareous soil. *Libyan Journal of Agricultural Sciences*, 27(1), 15–28.
18. Alhadad, A. (2018). Effects Of Pesticides On Human Health.
19. Lamma, O. A., & Amaref, M. A. (2025). Modern Olive Tree Irrigation and Fertilisation: Increasing Productivity and Sustainability. *Scientific Journal for Publishing in Health Research and Technology*, 118-128.
20. Ibrahim, O. M., & Bakr, W. A. (2022). Reclaiming calcareous soils using gypsum and organic compost: A sustainable approach for enhancing date palm productivity in arid regions. *Journal of Arid Environments*, 204, 104789.
21. Alhadad , A. (2022). HABITAT LOSS AND ITS EFFECT ON THE BIODIVERSITY: A REVIEW . *Journal of Azzaytuna University*, 44, 460-470.
<https://azzujournal.com/index.php/azujournal/article/view/172>
22. AsanousiLamma, O., Swamy, A. V. V. S., & Alhadad, A. A. (2018). Assessment of Heavy Metal Pollution in Ground Water and its Correlation with other Physical Parameters at Selected Industrial Areas of Guntur, AP, India.

Disclaimer/Publisher’s Note: The statements, opinions, and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of LJHSD and/or the editor(s). LJHSD and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions, or products referred to in the content.