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Phytotoxicity Assessment of Oat Seeds Using Purified Water Treated with Palm Leaves and Date Pits

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ABSTRACT

This work explores the potential toxicity of agricultural waste materials, specifically date palm seeds and palm fronds, on plant growth and health. These waste materials have shown promise as bioadsorbents for water purification, but their impact on plants needs to be understood. Toxicity assessments are crucial to ensure safe utilization and prevent negative effects on agricultural systems and ecosystems. Date palm seeds and palm fronds contain chemical compounds that can have allelopathic properties and influence neighboring plant growth. Experimental methods were employed to evaluate the phytotoxic effects of these materials, including germination assays and root growth inhibition tests. The results indicate that upon adsorption of PO4, palm leaves exhibited a significant enhancement in germination, leading to a remarkable increase of up to 371%. This outcome strongly emphasizes the effectiveness of palm leaves as vegetable fertilizers, highlighting their potential in agricultural applications. These findings contribute to understanding the phytotoxic potential of agricultural waste materials and developing sustainable utilization strategies.

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INTRODUCTION

The utilization of agricultural waste as a bioadsorbent for water purification has garnered significant attention in recent years. Agricultural waste materials, such as crop residues, fruit peels, date palm seeds, and palm fronds, have demonstrated promising potential as cost-effective and environmentally friendly alternatives for water treatment processes. These waste materials possess inherent adsorption properties that effectively remove various pollutants from water, including heavy metals, organic compounds, and nutrients. However, it is crucial to evaluate the potential toxicity effects of agricultural waste-derived bioadsorbents on plant growth and health (Barkat et al., 2023; Barkat et al., 2020; Barkat et al., 2021).

Assessing the toxicity of materials such as date palm seeds and palm fronds on plants is essential to comprehend their potential impact on plant growth and development. Date palm (Phoenix dactylifera) is extensively cultivated as a fruit tree in numerous regions, including the Middle East and North Africa, while palm fronds find application in animal feed and construction materials. Nevertheless, it is vital to evaluate the toxicity of these materials on plants to ensure their safe utilization and prevent any adverse effects on agricultural systems

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and natural ecosystems (Kyaw et al., 2022 ; Ruzickova, et al., 2021).

Toxicity refers to the harmful effects that a substance can have on living organisms. When it comes to plants, toxicity can manifest in different ways, such as reduced germination, inhibited root growth, impaired photosynthesis, or even plant death. It is crucial to assess the toxicity of date palm seeds and palm fronds on plants to understand their potential phytotoxic effects and make informed decisions about their use (Morel et al., 2004).

Date palm seeds contain various chemical compounds, including phenols, tannins, and alkaloids, which may exhibit allelopathic properties. Allelopathy refers to the ability of one plant species to release chemicals that affect the growth and development of other plants. Consequently, date palm seeds have the potential to inhibit the growth of neighboring plants through the release of allelochemicals (Azmi et al., 2020 ; Rahal et al.,2022 ; Azam et al., 2022).

In a similar vein, palm leaves consist of complex organic compounds like lignin and cellulose, which can degrade over time and release substances that may impact plant growth. It is vital to comprehend the potential phytotoxicity of palm fronds, particularly when they are utilized as mulch or incorporated into soil amendments (Rahal et al., 2022 ;Ravindran et al., 2014 ;Sharma et al., 2021).

Determining the toxicity of date palm seeds and palm fronds on plants requires conducting experiments and assessments. Various factors, including concentration, exposure duration, and plant species, must be taken into account during these investigations. Researchers employ techniques such as germination assays, root growth inhibition tests, and plant biomass measurements to evaluate potential phytotoxic effects (Sesin et al., 2021; Chapman et al., 2003; Simioni et al., 2023 ;Yang et al., 2015 ; Kalsch et al., 2006).

Assessing the phytotoxicity of date palm seeds and palm fronds is essential to comprehend their potential adverse effects on plant growth. Due to the allelopathic properties of date palm seeds and the organic composition of palm fronds, it is crucial to conduct thorough evaluations to ensure their safe utilization and prevent any detrimental impacts on plant growth and agricultural systems (Bumajdad et al.,2023; Rahal et al., 2023; Schmitt-Jansen et al., 2007; Maity et al.,, 2020 ;Balestri et al., 2019;Da Ros, Cinzia et al., 2018 ; Yang et al., 2015).

Date palm seeds contain compounds with allelopathic properties that can affect neighboring plants, while palm fronds' complex organic compounds may influence plant growth over time. Evaluating toxicity involves experiments considering concentration, exposure duration, and plant species, using techniques like germination assays and root growth inhibition tests. Understanding these factors is crucial for safe utilization and minimizing potential adverse effects on plants.

METHODS AND MATERIALS

Oat seeds

Oat seeds, also called oat kernels or oat kernels, are the seeds of the oat plant (Avena sativa) as shown in Figure 1. They are small, oval-shaped seeds that are commonly used as a nutritious cereal grain. Oat seeds are rich in dietary fiber, protein, vitamins and minerals, and they are often eaten as rolled oats or used in baking and cooking. Oat seeds have also been widely used in scientific research and experiments due to their consistent germination rates and suitability as a model test plant (Brtnický et al., 2019 ;Bilalis et al., 2013).

Safety Assessment of Palm Leaves and Date Pits for Agricultural Water Purification

Phosphates (PO_4), sulphuric acid (H_2SO_4), palm leaves, and date pits were used in this experiment as research-grade chemicals. Deionized water was utilized throughout the study. As the purpose of using the studied palm leaves and date pits is to purify agricultural waters, it is crucial to ensure that they do not introduce toxic or harmful substances into the water. To

Fig. 1. Dry healthy oat seeds

address this concern, an experimental method of waste phytotesting on plant seeds was applied following SP 2.1.7.1386-03 "Sanitary rules for determining the hazard class of toxic production and consumption wastes" (Barral et al. 2011). This method involves using oat seeds as a model test plant, which has been found to provide stable and reproducible data compared to other crop seeds. Intact oat seeds with a germination rate of at least 95% were selected for the experiment, as depicted in Figure 1.

Phytotoxicity and Germination Effects of Palm Leaves and Date Pits Extracts

The phytotoxicity of palm leaves and date pits was assessed by studying the biological effects of their aqueous extracts on test plant seeds. The experiments were conducted under conditions where the oat seeds were in direct contact with the extract in Petri dishes to observe their germination. This method of exposure was chosen for its convenience and technical simplicity.

To prepare the samples for phytotoxicity testing, distilled water with an initial pH level of 6.7-6.8 was used as the extraction medium (extractant) to extract chemicals from the waste materials. Samples were prepared by placing 10 g of raw palm leaves, palm leaves after adsorption, raw date pits, and activated H_2SO_4 in 100 ml volumetric flasks, which were then filled to the mark with distilled water. Working solutions were prepared by diluting the original extract in a sequential manner. After thorough stirring, the flasks containing the extracts were allowed to stand at room temperature for a day and then filtered using a "blue ribbon" filter.

The experimental studies were conducted in three stages: checking the germination of the seeds, determining the range of phytotoxic effects, and establishing phytotoxicity parameters.

Sterilized Petri dishes containing filter paper circles are prepared and allowed to cool. On the outer side of the lids, markings are made, including the sample names (control, types of palm leaves, and date pits), along with the value of R (dilution factor) = 1.

In each Petri dish, 30 dry and healthy oat seeds are placed. It is ensured that the selected seeds have a germination rate of at least 95%, as depicted in Figure 2. This selection is made to guarantee a high likelihood of seedling growth. These seeds serve as a distinctive group utilized in the upcoming experiment. Such selection contributes to obtaining precise and reliable results in research that necessitates uniform growth and high germination percentages.

Germination and Phytotoxicity Assessment of Seedlings

When determining the germination percentage, the seeds were germinated using distilled water as the substrate. A volume of 5 ml of distilled water was applied to the filter paper in each closed cup, which was then placed in a thermostat at a temperature of 20-23 °C for 3 days. After

Fig. 2. Oat seeds in Petri dishes.

this period, the percentage of germinated seeds was calculated. In the experimental cups, 5 ml of rice straw extract was added, while the control seeds were treated with an appropriate amount of distilled water. All samples were kept in the thermostat for 7 days. At the end of the exposure period, the length of the roots of both the control and experimental seedlings was measured, with the longest root serving as the measurement criterion for each seed. Subsequently, the obtained experimental data underwent statistical processing. The phytotoxic effect was determined by comparing the parameters of the Lcp test function between the control and experimental seeds. The Lcp value was calculated as the arithmetic mean of the root length data for seedlings, according to formula (1) (Barral et al., 2011;SP 2.1.7.1386-03 ;Libralato et al., 2016).

$$L_{cp} = \frac{\Sigma L_i}{n} , \quad (1)$$

Where ∑Li is the total length of the maximum root of each seed, mm;
n is the total number of seeds taken in the experiment.
The magnitude of the braking effect is determined by the formula (2):

$$E_T = \frac{L_c - L_{ex}}{L_c} .100\ \% \quad (2)$$

Where, Eт is the braking effect, %;
Lex is the average length of roots in the experiment, mm;
Lc is the average length of the roots in the control, mm.
If the value of Lcp(ex) is greater than or equal to the value of Lcp(c), then there is no adverse effect of withdrawal.
A phytotoxic effect is considered proven if the value of the inhibitory effect Et is 20% or more.

RESULTS AND DISCUSSION

The Lcp values, representing the Local Coverage Probability, were obtained through a series of experiments designed to analyze and measure the effectiveness of a specific method or model. The resulting data, shown in Figure 3, illustrates the range of Lcp values observed across the experiments. This visual representation provides a comprehensive view of the distribution and

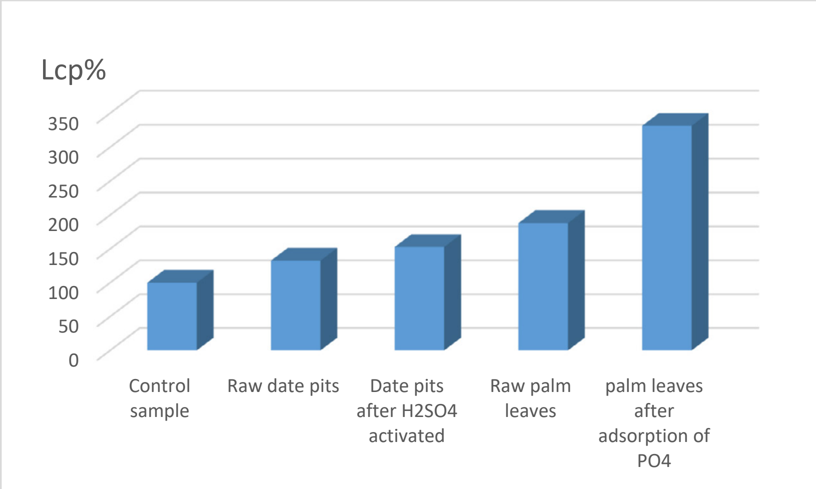

Fig. 3. Values (Lcp - average root length) for the palm leaves and date pits

Table 1. Results of the experiment to determine the phytotoxicity of palm leaves and date pits

Picture of the experiment	Characteristics and results of the experiment	
Control sample		
	Extract dilution, R	1
	Average length of seedling roots, Lcp, cm	6,21
	Lcp %	100
	Phytoeffect, ET, %	00,00
	Test reaction	Control
Raw date pits		
	Extract dilution, R	1
	Average length of seedling roots, Lcp, cm	8,24
	Lcp %	132,69
	Phytoeffect, ET, %	-32,69
	Test reaction	Normally

Contiued Table 1. Results of the experiment to determine the phytotoxicity of palm leaves and date pits

Picture of the experiment	Characteristics and results of the experiment	
Date pits after H_2SO_4 activated		
	Extract dilution, R	1
	Average length of seedling roots, Lcp, cm	9,54
	Lcp %	152,88
	Phytoeffect, ET, %	-52,88
	Test reaction	Normally
Raw palm leaves		
	Extract dilution, R	1
	Average length of seedling roots, Lcp, cm	11,74
	Lcp %	188,14
	Phytoeffect, ET, %	-88,14
	Test reaction	Normally
palm leaves after adsorption of PO_4		
	Extract dilution, R	1
	Average length of seedling roots, Lcp, cm	20,68
	Lcp %	331,41
	Phytoeffect, ET, %	-231,44
	Test reaction	Normally

variability of the Local Coverage Probability.

The data presented in Figure 3 and Table 1 provide evidence that palm leaves and date pits do not exhibit harmful or toxic effects, as there was no observed negative impact on the germination rate of oat seeds. Additionally, the results indicate that palm leaves, particularly after undergoing adsorption of PO_4, resulted in a significant improvement in germination by up to 331%. This finding suggests the potential use of palm leaves as a vegetable fertilizer in agricultural practices.

CONCLUSION

This scientific study demonstrates the promising potential of palm leaves and date pits as beneficial resources in the agricultural industry. The results indicate that these materials have no detrimental effects, as evidenced by their positive impact on oat seed germination rates. Notably, the adsorption of PO_4 by palm leaves significantly enhanced germination, resulting in an impressive increase of up to 371%. This finding underscores the viability of palm leaves as effective vegetable fertilizers. By incorporating palm leaves and date pits into agricultural practices, it is possible to enhance crop production while promoting sustainable farming methods. This utilization of natural materials as fertilizers offers an opportunity to reduce dependence on synthetic alternatives, thereby mitigating environmental pollution and lowering production costs for farmers.

Further research is needed to delve into the underlying mechanisms driving the observed improvements in germination and to assess the long-term effects of palm leaves and date pits as vegetable fertilizers. Additionally, exploring optimal application rates and methods of incorporating these materials into the soil would be beneficial for maximizing their potential benefits in agricultural practices.

It is strongly recommended that subsequent studies focusing on the assessment of phytotoxicity against heavy metals be established. Understanding the potential harm heavy metals may pose to plants and ecosystems is crucial for environmental protection. Further research in this area will provide valuable insights into the mechanisms of phytotoxicity and aid in the development of effective mitigation strategies.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

REFERENCES

Barkat, A., Bouaicha, F., Bouteraa, O., Mester, T., Ata, B., Balla, D., Rahal, Z., & Szabó, G. (2021). Assessment of complex terminal groundwater aquifer for different use of Oued Souf valley (Algeria) using multivariate statistical methods, geostatistical modeling, and water quality index. Water, 13(11), 1609.

Barkat, A., Bouaicha, F., Mester, T., Debabeche, M., & Szabó, G. (2022). Assessment of spatial distribution and temporal variations of the phreatic groundwater level using geostatistical modelling: the case of oued souf valley—southern East of Algeria. Water, 14(9), 1415.

Kyaw, E. H., Iwasaki, A., Suenaga, K., & Kato-Noguchi, H. (2022). Assessment of the Phytotoxic Potential of Dregea volubilis (Lf) Benth. ex Hook. f. and Identification of its Phytotoxic Substances for Weed Control. Agriculture, 12(11), 1826.

Ruzickova, J., Koval, S., Raclavska, H., Kucbel, M., Svedova, B., Raclavsky, K., Juchelkova, D., & Scala, F. (2021). A comprehensive assessment of potential hazard caused by organic compounds in biochar for agricultural use. Journal of hazardous materials, 403, 123644.

Morel, P., & Guillemain, G. (2004). Assessment of the possible phytotoxicity of a substrate using an easy and representative biotest. Acta Horticulturae, 417-424.

Rahal, Z., Chekima, H., Smolyanichenko, A. S., & Serpokrylov, N. S. (2022). Use of date seals as a potential adsorbent for groundwater purification. Engineering and Construction Bulletin of the Caspian Region, (4 (42)), 26-29.

Azam, M., Khan, M. R., Wabaidur, S. M., Al-Resayes, S. I., & Islam, M. S. (2022). Date pits waste as a solid phase extraction sorbent for the analysis of lead in wastewater and for use in manufacturing brick: An eco-friendly waste management approach. Journal of Saudi Chemical Society, 26(5), 101519.

Azmi, S. N. H., Al-Balushi, M., Al-Siyabi, F., Al-Hinai, N., & Khurshid, S. (2020). Adsorptive removal of Pb (II) ions from groundwater samples in Oman using carbonized Phoenix dactylifera seed (Date stone). Journal of King Saud University-Science, 32(7), 2931-2938.

Rahal, Z., Chekima, H., & Serpokrylov, N. S. (2022). use of palm leaves as a potential adsorbent for wastewater treatment. Engineering and Construction Bulletin of the Caspian Region, (3 (41)), 37-43.

Ravindran, B., Contreras-Ramos, S. M., Wong, J. W. C., Selvam, A., & Sekaran, G. (2014). Nutrient and enzymatic changes of hydrolysed tannery solid waste treated with epigeic earthworm Eudrilus eugeniae and phytotoxicity assessment on selected commercial crops. Environmental Science and Pollution Research, 21, 641-651.

Sharma, P., & Kumar, S. (2021). Characterization and phytotoxicity assessment of organic pollutants in old and fresh municipal solid wastes at open dump site: A case study. Environmental Technology & Innovation, 24, 101938.

Sesin, V., Davy, C. M., & Freeland, J. R. (2021). Review of typha spp.(cattails) as toxicity test species for the risk assessment of environmental contaminants on emergent macrophytes. Environmental Pollution, 284, 117105.

Chapman, P. M., Wang, F., Janssen, C. R., Goulet, R. R., & Kamunde, C. N. (2003). Conducting ecological risk assessments of inorganic metals and metalloids: current status. Human and ecological risk assessment, 9(4), 641-697.

Simioni, T., Agustini, C. B., Dettmer, A., & Gutterres, M. (2023). Use of tannery waste anaerobic digestate as agricultural fertilizer: an analysis of oat growth and soil fertility. Waste and Biomass Valorization, 14(4), 1197-1206.

Mabovu, B. (2011). Brine treatment using natural adsorbents (Doctoral dissertation, University of the Western Cape).

Kermerchou, I., Mahdjoubi, I., Kined, C., Khechekhouche, A., Bellila, A., & Isiordia, G. E. D. (2022). Palm fibers effect on the performance of a conventional solar still. ASEAN Journal for Science and Engineering in Materials, 1(1), 29-36.

Bumajdad, A., & Hasila, P. (2023). Surface modification of date palm activated carbonaceous materials for heavy metal removal and CO2 adsorption. Arabian Journal of Chemistry, 16(1), 104403.

Barkat, A., Bouaicha, F., Rahal, Z., Mester, T & Szabó. (2023). Evaluation of climatic conditions from 1978 to 2020 of oued souf valley (southern east of Algeria). Landscape & Environment.

Rahal, Z., K, Abderrahmane., Barkat, A., Smolyanichenko, A, S., Chekima, H. (2023). Adsorption of sodium in an aqueous solution in activated date pits. Indonesian Journal of Science & Technology, 8(3) 397-412.

Schmitt-Jansen, M., Bartels, P., Adler, N., & Altenburger, R. (2007). Phytotoxicity assessment of diclofenac and its phototransformation products. Analytical and bioanalytical chemistry, 387, 1389-1396.

Maity, S., & Pramanick, K. (2020). Perspectives and challenges of micro/nanoplastics-induced toxicity with special reference to phytotoxicity. Global Change Biology, 26(6), 3241-3250. Balestri, E.,

Menicagli, V., Ligorini, V., Fulignati, S., Galletti, A. M. R., & Lardicci, C. (2019). Phytotoxicity assessment of conventional and biodegradable plastic bags using seed germination test. Ecological indicators, 102, 569-580.
Da Ros, C., Libralato, G., Ghirardini, A. V., Radaelli, M., & Cavinato, C. (2018). Assessing the potential phytotoxicity of digestate from winery wastes. Ecotoxicology and environmental safety, 150, 26-33.
Yang, Z., Chen, J., Dou, R., Gao, X., Mao, C., & Wang, L. (2015). Assessment of the phytotoxicity of metal oxide nanoparticles on two crop plants, maize (Zea mays L.) and rice (Oryza sativa L.). International journal of environmental research and public health, 12(12), 15100-15109.
Kalsch, W., Junker, T., & Römbke, J. (2006). A chronic plant test for the assessment of contaminated soils. Part 1: method development (9 pp). Journal of Soils and Sediments, 6, 37-45.
Bilalis, D. J., Travlos, I. S., Karkanis, A., Gournaki, M., Katsenios, G., Hela, D., & Kakabouki, I. (2013). Evaluation of the allelopathic potential of quinoa (Chenopodium quinoa Willd.). Romanian Agricultural Research, 30, 359-364.
Brtnický, M., Pecina, V., Hladký, J., Radziemska, M., Koudelková, Z., Klimánek, M., Lukáš, R., Dana, A., Jakub, E., Michaela, V, G., Ludmila, B., Jindřich, K.,Vendula, S., Jakub, H & Vaverková, M. D. (2019). Assessment of phytotoxicity, environmental and health risks of historical urban park soils. Chemosphere, 220, 678-686.
Libralato, G., Devoti, A. C., Zanella, M., Sabbioni, E., Mičetić, I., Manodori, L., A. Pigozzo., S. Manenti., F. Groppi & Ghirardini, A. V. (2016). Phytotoxicity of ionic, micro-and nano-sized iron in three plant species. Ecotoxicology and Environmental Safety, 123, 81-88.
Barral, M. T., & Paradelo, R. (2011). A review on the use of phytotoxicity as a compost quality indicator. Dyn. Soil Dyn. Plant, 5(2), 36-44.
SP 2.1.7.1386-03 “Sanitary rules for determining the hazard class of toxic production and consumption wastes”.