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Laboratory evaluation of the chemical and qualitative content of several phosphate fertilizers used in agricultural systems compared to the organic fertilizer

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ABSTRACT

The physicochemical characteristics of fertilizers play a critical role in determining nutrient availability, fertilizer efficiency, and soil chemical reactions after application. This laboratory study aimed to evaluate the chemical properties and nutrient composition of several phosphate and organic fertilizers commonly used in agricultural systems. Four fertilizer sources were investigated, including Jordanian DAP, Saudi DAP, British DAP, and organic fertilizer. Laboratory analyses included electrical conductivity (EC), pH, total solids (TS), total dissolved solids (TDS), solubility percentage, calcium, magnesium, chloride, nitrogen, phosphorus, and potassium concentrations. The results revealed substantial variation among fertilizer sources in ionic concentration, dissolution behavior, and nutrient composition. Mineral fertilizers exhibited markedly higher EC and TDS values compared with organic fertilizer, indicating greater ionic strength and salinity potential. Organic fertilizer showed the highest solubility percentage (93.88%) and the greatest concentrations of nitrogen, phosphorus, and potassium. British DAP fertilizer recorded the highest phosphorus concentration among mineral fertilizers. Variations among fertilizers were attributed to differences in raw material composition, manufacturing processes, and nutrient-bearing compounds. The study confirmed that laboratory evaluation represents an effective approach for predicting fertilizer quality, nutrient release dynamics, and their potential impact on soil chemical behavior.

1- INTRODUCTION

Mineral and organic fertilizers are among the most important factors responsible for improving soil fertility and increasing the availability of essential nutrients for plants. They play a fundamental role in enhancing agricultural production efficiency and improving plant growth (Havlin et al., 2019). However, fertilizer efficacy does not depend solely on the concentrations of the nutrients they contain, but is directly related to their chemical and physical properties, as well as their solubility, decomposition, and release in aqueous environments (Marschner, 2021). Laboratory evaluation of fertilizers is a crucial tool for understanding their chemical behavior before field application. It provides accurate indicators of electrical conductivity, reactivity, solubility, and soluble solids, in addition to assessing the elemental content and nutrient availability (Brady & Weil, 2017). These properties also directly influence chemical processes within the soil, such as adsorption, precipitation, ion exchange, and the biotransformation of nutrients (Sparks, 2020). Diammonium phosphate (DAP) is one of the most widely used fertilizers globally due to its high nitrogen and phosphorus content, ease of application, and high agricultural efficiency (Fageria, 2016). However, variations in the sources used to manufacture this fertilizer lead to significant differences in its chemical properties, resulting from variations in the type of phosphate rock, raw materials used, and manufacturing and purification techniques (IFA, 2021).

Organic fertilizers are also characterized by their ability to improve the chemical and biological environment of the soil by increasing organic matter, enhancing cation exchange capacity, and reducing nutrient fixation within the soil (Stevenson & Cole, 2015). Furthermore, the decomposition of organic matter produces organic and humic acids, which contribute to increased solubility of some nutrients and reduced precipitation (Tan, 2014). The chemical properties of fertilizers directly affect the availability of nutrients in the soil. High electrical conductivity reflects increased ionic strength of the solution and a higher concentration of soluble salts, while pH influences nutrient solubility and chemical equilibrium (Mengel & Kirkby, 2001). Nitrogen, phosphorus, and potassium concentrations are key indicators for evaluating the fertilization value and agricultural efficiency of different fertilizers (Jones, 2012). Therefore, this study aims to conduct a comprehensive laboratory evaluation of several phosphate and organic fertilizers by examining their chemical properties, solubility, and elemental content to determine their potential efficiency and chemical behavior under laboratory conditions.

2-Materials and Methods

The study included four types of fertilizers: Jordanian DAP, Saudi DAP, British DAP and Organic fertilizer. The experiment units were distributed according to a completely randomized design CRD with three replications.

Laboratory Analyses

Laboratory analyses were conducted according to standard methods adopted in soil science and fertilizer laboratories (Page et al., 1982; Jones, 2012)l the measurements included: electrical conductivity (EC) at extraction ratios of 1:1 and 1:10, pH, total solids (TS), total soluble solids (TDS), calcium (Ca), magnesium (Mg), chloride (Cl), solubility, nitrogen (N), phosphorus (P), and potassium (K). The data were statistically analyzed with the aid of GenStat 12th software (Payne et al., 2009) performing analysis of variance (ANOVA). The significance of the differences among treatments was tested at probability levels of 0.05, 0.01, and 0.001 (Hoshmand, 2018).

3-Results and Discussion

Electrical Conductivity (EC) and pH

The results showed a significant increase in the electrical conductivity of mineral fertilizers compared to the organic fertilizers. Saudi DAP recorded the highest EC value at a 1:1 extraction of 78.4 dS m^{-1}, followed by Jordanian DAP at 77.5 dS m^{-1} and British DAP at 75.4 dS m^{-1}. Organic fertilizers, on the other hand, recorded the lowest EC value at 10.25 dS

m^{-1} (Figure1, A). The results also showed a decrease in EC values at a 1:10 dilution, reaching 48.5, 43.1, and 33.4 dS m^{-1} for Saudi, Jordanian, and British DAP, respectively, while it reached 4.86 dS m^{-1} for organic fertilizer. Whereas, pH values ranged from 6.46 to 7.45, with organic fertilizer recording the lowest pH at 6.46 and Saudi DAP recording the highest at 7.45 (Figure1, B).

The high EC value in DAP fertilizers reflects the high concentration of soluble salts and mobile free ions, particularly NH_4^+, $H_2PO_4^-$, K^+, Ca_2^+, and Mg_2^+ ions, which lead to an increase in the ionic strength of the solution (Sparks, 2020). These results also indicate a higher rate of decomposition of mineral compounds and the immediate release of nutrients after dissolution. Electrical conductivity (EC) is one of the most important chemical indicators used to evaluate fertilizer quality because it is directly related to the fertilizer's potential impact on soil salinity and the osmotic pressure of the soil solution (Brady & Weil, 2017). A high EC can lead to a decrease in the osmotic potential of water, thus limiting the roots' ability to absorb water, especially in arid and semi-arid environments (Richards, 1954). The significant decrease in EC of organic fertilizer is linked to the complex nature of organic compounds, which do not fully decompose or ionize in aqueous environments, as well as the low concentration of free mineral salts (Stevenson & Cole, 2015). This indicates a difference in the nature of ionic dissociation among fertilizers, as some mineral compounds have a higher capacity to maintain ionic equilibrium even at dilution levels (Tan, 2014).

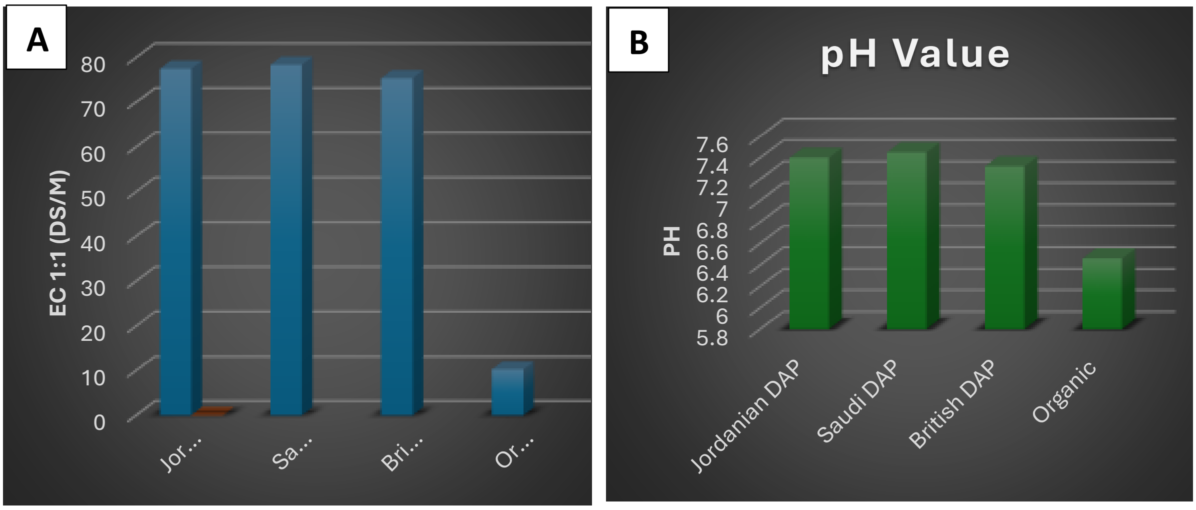

Figure 1. Electrical conductivity (A) and pH (B) values of different types of commercial mineral fertilizers compared to organic fertilizer

These results indicate that DAP fertilizers have a neutral to slightly alkaline reaction due to their content of ammonium compounds, phosphates, and basic cations such as calcium and magnesium (Mengel & Kirkby, 2001). Furthermore, the presence of ammonia in the chemical composition of DAP fertilizers contributes to a relatively high pH as a result of decomposition and chemical reactions. The presence of ammonia in the chemical composition of DAP fertilizers contributes to a relatively high pH due to decomposition and chemical reactions. The relatively low pH of organic fertilizers is attributed to the presence of organic acids resulting from the decomposition of organic compounds, such as humic, fulvic, and carboxylic acids (Stevenson & Cole, 2015). pH is one of the most important factors controlling the solubility and chemical balance of nutrients. High pH values increase the precipitation of phosphorus with calcium, while moderately acidic values increase nutrient solubility and reduce nutrient fixation (Marschner, 2021).Stability of pH values within the range close to neutral indicates fertilizer quality and chemical stability. Extreme decreases or increases in pH can lead to the decomposition of some compounds or the loss of nutrients during storage (IFA, 2021).

Total and Dissolved Solids (TS and TDS)

The Saudi DAP recorded the highest total solids value (TS) at 36.1 g L^{-1}, while organic fertilizer recorded the lowest value at 10.2 g L^{-1} (Figure 2, A). TDS reached its highest value in Saudi DAP at 19,430 ppm, compared to 19,229 and 15,550 ppm for Jordanian and British DAP, respectively, while organic fertilizer recorded only 3,220 ppm (Figure 2, B). These results indicate a high concentration of soluble mineral compounds in DAP fertilizers, leading to increased concentrations of free ions in the solution (Richards, 1954). Furthermore, high TDS is associated with increased osmotic pressure and high ionic strength of the fertilizer solution (Sparks, 2020). Conversely, the low TS and TDS in organic fertilizer are linked to the presence of a large proportion of non-ionized or slow-dissolving organic compounds, giving this type of fertilizer the characteristic of gradual nutrient release (Tan, 2014).

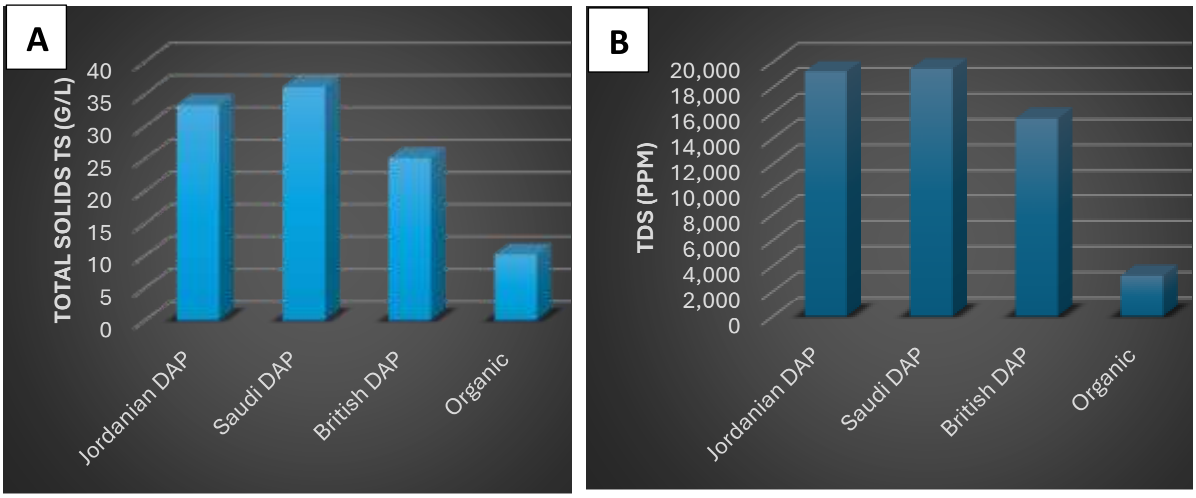

Figure 2. Differences in total dissolved soils TS (A) and TDS (B) among different types of commercial mineral fertilizers compared to organic fertilizer

Calcium, Magnesium, Chloride, and Solubility

Saudi DAP recorded the highest calcium concentration at 1900 ppm, while British DAP recorded the highest magnesium concentration at 1212 ppm, and Jordanian DAP recorded the highest chloride concentration at 2535 ppm (Figure 3, A, B and C). The high calcium and magnesium levels are attributed to the nature of the phosphate rocks used in manufacturing, as some phosphate ores contain high percentages of carbonates and secondary minerals (IFA, 2021). The high chloride levels may indicate the presence of salt impurities or the use of raw materials with a high chloride content, which can affect fertilizer quality, especially when used with salt-sensitive crops (Havlin et al., 2019). The results showed a clear variation in solubility percentages, with organic fertilizer recording the highest percentage at 93.88%, compared to 17.94%, 7.28%, and 6.68% for Jordanian, British, and Saudi DAP, respectively (Figure 3, D). Solubility is one of the most important chemical indicators for evaluating fertilizer efficiency, as it determines the rate at which nutrients are released and translocated in the soil solution (Marschner, 2021). High solubility of organic fertilizers indicates the ease with which their components decompose and break down in the aqueous medium, while low values for DAP fertilizers reflect the presence of more stable or less decomposed phosphate compounds (Tan, 2014).

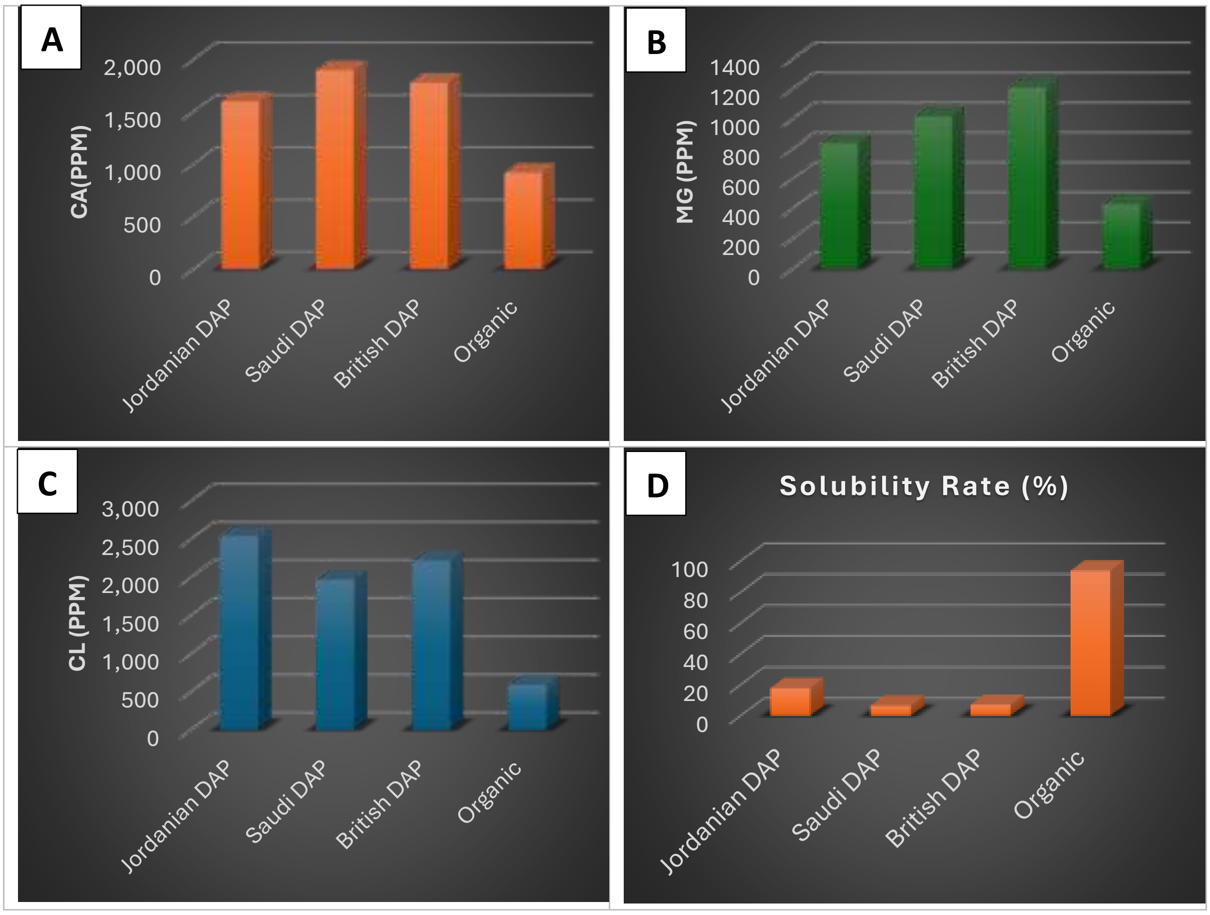

Figure 3. Differences in fertilizer content of Calcium (A), Potassium (B), Chloride (C) and solubility rate (D) among different types of commercial mineral fertilizers compared to organic fertilizer

Nitrogen, Phosphorus, and Potassium

Laboratory analysis revealed a clear variation in nitrogen concentrations among the studied fertilizers. Organic fertilizer recorded the highest nitrogen concentration at 63.8 g kg^{-1}, followed by British DAP at 36.1 g kg^{-1}, then Jordanian DAP at 28.1 g kg^{-1}, while Saudi DAP recorded the lowest concentration at 23.7 g kg^{-1} (Figure 4, A). The study also showed significant differences in phosphorus concentrations among the fertilizers used (Figure 4, B). Organic fertilizer recorded the highest concentration at 81.1 g kg^{-1}, followed by British DAP at 53.6 g kg^{-1}, then Jordanian DAP at 47.9 g kg^{-1}, while Saudi DAP recorded the lowest value at 36 g kg^{-1}. Laboratory analysis results showed that organic fertilizer had the highest potassium concentration of 130.7 g kg^{-1}, followed by Jordanian DAP at a concentration of 104.9 g kg^{-1}, then British DAP at 104.1 g kg^{-1}, while Saudi DAP recorded the lowest concentration of 78.6 g Kg^{-1} (Figure 4, D).

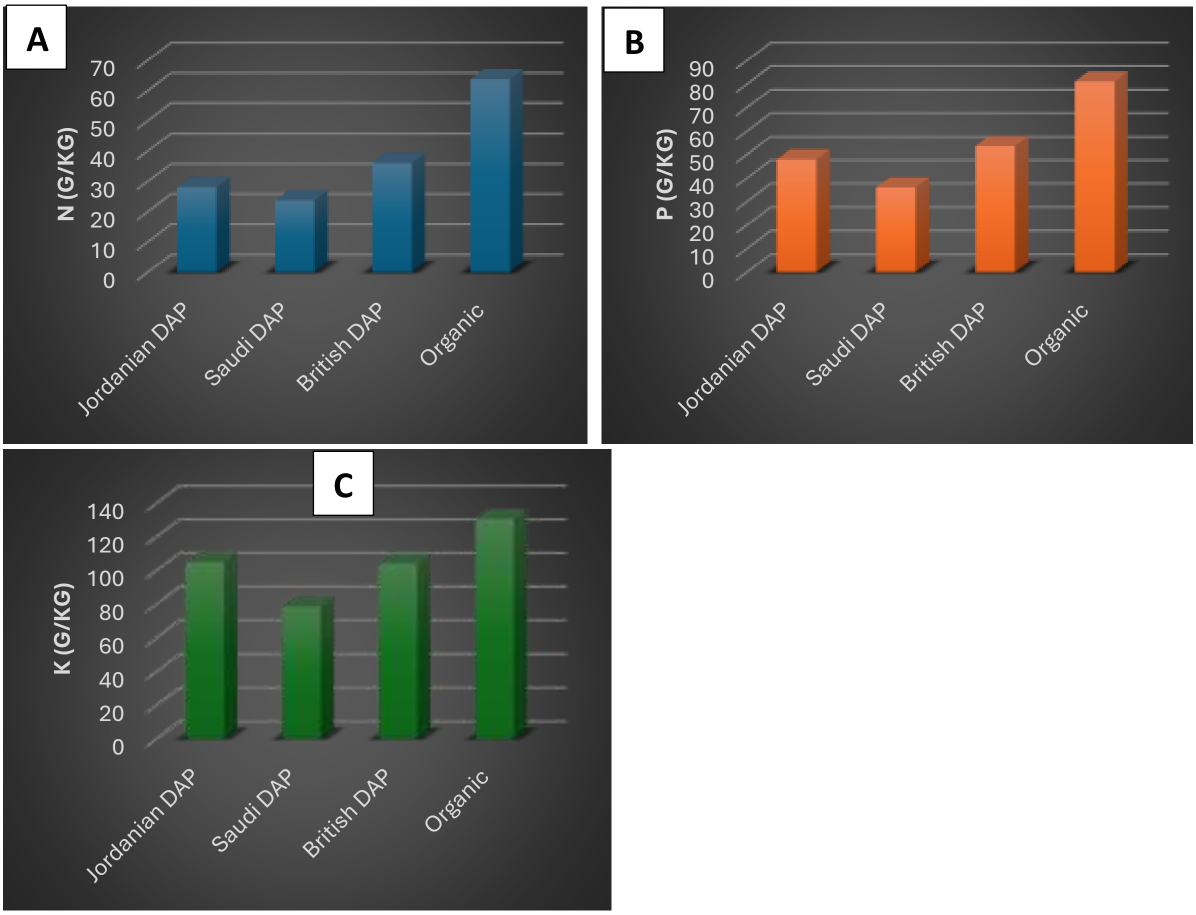

Figure 4. Differences in nitrogen, phosphorus and potassium content values total dissolved among different types of commercial mineral fertilizers compared to organic fertilizer

4-Discussion

These results indicate a clear variation in the chemical composition and sources of raw materials used in the manufacture of these fertilizers, as well as differences in the efficiency of manufacturing and industrial processing operations. Nitrogen is considered one of the most dynamic nutrients in soil and is closely associated with the biological and chemical processes that regulate plant growth and productivity. Therefore, evaluating its concentration in fertilizers represents an important indicator of their potential fertilizing efficiency (Luce et al., 2011).

Nitrogen in DAP fertilizers is predominantly present in the ammoniacal form (NH_4^+), which is highly soluble and readily released into the soil solution, resulting in an immediate increase in nitrogen availability following application. However, this form of nitrogen is more susceptible to nitrification and biological transformation processes in soil, which subsequently lead to the formation of nitrate (NO_3^-), a highly mobile form prone to leaching losses (Gworek et al., 2021). The conversion of ammonium to nitrate is considered one of the most important processes affecting nitrogen use efficiency and nitrogen losses from soil, particularly under conditions favorable for microbial activity.

The higher nitrogen content observed in the British DAP fertilizer compared with the Jordanian and Saudi DAP fertilizers may indicate a higher proportion of active ingredients or a lower content of non-nutritive mineral impurities. It may also reflect greater efficiency in manufacturing and chemical crystallization processes. In contrast, the relatively lower nitrogen content in the Saudi DAP fertilizer may be associated with a higher salt content or an increased proportion of non-nitrogenous compounds incorporated into the final fertilizer composition (Becker, 1989; Ryszko et al., 2023).

Conversely, the markedly higher nitrogen content in the organic fertilizer is not only attributable to its total nitrogen content but also reflects the presence of complex organic nitrogen compounds such as amino acids, proteins, and humic substances. These compounds are characterized by gradual decomposition through microbial activity, providing a sustainable and slow-release source of nitrogen compared with highly soluble mineral fertilizers. Moreover, organically bound nitrogen possesses significant environmental and chemical advantages, as it is less susceptible to losses through leaching or volatilization than mineral fertilizers, thereby enhancing nitrogen use efficiency in soil and ensuring a release pattern that is more closely aligned with the physiological requirements of plants (Gworek et al., 2021).

From a chemical perspective, the elevated nitrogen concentration in organic fertilizer may stimulate microbial activity in soil, particularly among microorganisms responsible for organic matter decomposition, leading to increased mineralization rates and improved nutrient cycling. In addition, the decomposition of organic nitrogen compounds generates organic acids and carbon dioxide, which may indirectly enhance the solubility of other nutrients such as phosphorus and micronutrients. Studies have indicated that most soil nitrogen exists in organic forms associated with soil organic matter and that microbial mineralization processes represent the primary pathway for converting organic nitrogen into mineral forms available for plant uptake (Walworth, 2013).

The results also suggest that variations in nitrogen concentrations among mineral fertilizers reflect differences in the sources of phosphate rocks used in production, as well as differences in the efficiency of the reaction between ammonia and phosphoric acid during manufacturing. Industrial factors such as temperature, moisture content, and raw material purity influence the final composition of the fertilizer and its capacity to retain nitrogen. Furthermore, the quality of raw materials used in phosphate fertilizer production is considered one of the principal factors affecting the characteristics of the final product and its nutrient concentration (Becker, 1989; Ryszko et al., 2023; Jasinski, 2015).

Overall, the higher nitrogen content in both the organic fertilizer and the British DAP fertilizer provides an important agronomic advantage in terms of supplying this essential nutrient. However, their release patterns differ substantially; mineral fertilizers are characterized by rapid nutrient release and immediate plant response, whereas organic fertilizer is distinguished by gradual nutrient release and long-term nutrient sustainability, thereby improving nitrogen use efficiency and reducing environmental losses over the long term (Luce et al., 2011; Gworek et al., 2021).

Phosphorus is considered one of the most chemically complex plant nutrients due to its rapid susceptibility to fixation and precipitation processes, particularly in calcareous soils rich in calcium, where phosphate ions tend to form sparingly soluble compounds such as dicalcium and tricalcium phosphate, thereby reducing its availability to plants (Johan et al., 2021). Therefore, the evaluation of phosphorus content in fertilizers is not based solely on the total phosphorus concentration but also on the nature of phosphate compounds, their solubility, and their release efficiency in soil. The higher phosphorus content observed in the British DAP fertilizer compared with the other DAP fertilizers indicates a higher proportion of active phosphate material and may also reflect the use of purer phosphate rocks with lower levels of mineral impurities during manufacturing. The quality of phosphate rocks directly affects fertilizer quality, as impurities such as calcium, magnesium, iron, and aluminum in the raw material may influence phosphoric acid production efficiency and the quality of the resulting phosphate fertilizers (Ryszko et al., 2023). In contrast, the relatively lower phosphorus content in the Saudi DAP fertilizer may be associated with a higher content of salts or non-phosphate compounds, or with differences in manufacturing conditions that affect the conversion rate to the soluble form. Conversely, the organic fertilizer is characterized by its high phosphorus content, reflecting the presence of organic residues rich in decomposed phosphate compounds. Moreover, phosphorus in organic fertilizers is often associated with organic and humic compounds that contribute to reducing its rapid fixation in soil. Organic acids released during the decomposition of organic matter form complexes with calcium, iron, and aluminum, thereby limiting phosphorus precipitation and maintaining it in a more plant-available form (Jindo et al., 2023).

Generally, the high concentration of soluble phosphorus in mineral fertilizers leads to a rapid increase in phosphate ion concentration within the soil solution. However, this increase may be temporary due to the subsequent exposure of phosphorus to adsorption and precipitation processes. In contrast, organic phosphorus is gradually released through microbial activity, enhancing its long-term availability in soil. Furthermore, variations in phosphorus concentrations among different DAP fertilizers may reflect differences in the efficiency of the industrial reaction between ammonia and phosphoric acid during fertilizer production, as the precision of manufacturing control and the purity of raw materials influence the final phosphorus concentration and its degree of solubility (Ryszko et al., 2023). Overall, the higher phosphorus content in the organic fertilizer and the British DAP fertilizer indicates their high fertilizing value. However, the mechanism of nutrient supply differs between them; DAP provides phosphorus in a rapidly soluble form, whereas organic fertilizer supplies phosphorus gradually and in a more chemically stable form.

Potassium is one of the essential nutrients responsible for regulating osmotic balance, activating enzymes, stimulating photosynthesis, and facilitating carbohydrate translocation within plants. Unlike nitrogen and phosphorus, potassium generally does not form part of complex organic compounds but exists primarily as a free ionic form (K^+), which makes it more mobile and readily soluble (Hasanuzzaman et al., 2018; Johnson et al., 2022). The markedly high potassium content in the organic fertilizer indicates that the organic material contains substantial amounts of potassium released from plant residues and decomposed organic matter. Furthermore, the association of a portion of potassium with organic complexes and colloids may reduce its loss compared with mineral fertilizers. In contrast, the elevated potassium content in the Jordanian and British DAP fertilizers may reflect the presence of potassium-rich additives or impurities originating from the raw materials used during production, as some phosphate rocks may contain clay minerals or potassium salts associated with the phosphate ore (Ryszko et al., 2023).

From a chemical perspective, potassium is characterized by its rapid dissolution and movement within the soil solution compared with phosphorus because it is not subject to precipitation reactions to the same extent. Nevertheless, a portion of potassium may become fixed within the interlayer spaces of certain clay minerals, such as illite and vermiculite, thereby reducing its immediate availability in some soil types (Portela et al., 2019). Moreover, high potassium concentrations in fertilizers contribute to an increase in the ionic strength of the fertilizer solution, which may partially explain the elevated EC and TDS values observed in some mineral fertilizers. The presence of potassium, calcium, magnesium, and chloride in DAP fertilizers, despite the fact that the theoretical composition of the fertilizer is based primarily on nitrogen and phosphorus, is considered a natural phenomenon from both chemical and industrial perspectives. This is related to the nature and purity of the phosphate rocks used in manufacturing, as well as to the processing, purification, and granulation operations, through which varying amounts of mineral elements and impurities may be transferred from the raw materials to the final product (Ryszko et al., 2023).

Laboratory analysis revealed that the DAP fertilizers under study contained varying concentrations of potassium, calcium, magnesium, and chloride, although the theoretical chemical composition of DAP fertilizer is primarily represented by diammonium phosphate $(NH_4)_2HPO_4$, commercially known as 18–46–0, which serves as a major source of nitrogen and phosphorus without the direct addition of potassium or other secondary nutrients. However, the presence of these elements in the current results reflects the practical nature of commercially manufactured fertilizers, which differ from the pure chemical formulation produced under laboratory conditions (Ryszko et al., 2023). The primary reason for the presence of calcium, magnesium, chloride, and potassium in DAP fertilizers is related to the nature of the phosphate rocks used in the production of phosphoric acid, which is the main raw material for DAP fertilizer manufacturing. Phosphate rocks naturally contain mineral impurities and associated minerals such as calcite, dolomite, feldspars, and soluble salts, which serve as sources of secondary elements and accompanying ions in the final fertilizer product (Ryszko et al., 2023; Becker, 1989). Furthermore, DAP production involves the neutralization of phosphoric acid with ammonia under specific industrial conditions. However, phosphoric acid produced through the Wet Process is not completely pure and contains varying amounts of dissolved mineral elements derived from phosphate ore, including calcium, magnesium, iron, aluminum, and certain soluble salts (Becker, 1989).

The elevated calcium content observed in some DAP fertilizers may be attributed to the high concentration of carbonate minerals in the phosphate rocks, as many sedimentary phosphate deposits contain considerable amounts of calcite and dolomite associated with phosphate apatite minerals. During the treatment of phosphate rock with sulfuric acid for phosphoric acid production, portions of calcium and magnesium may be transferred to the final product in the form of dissolved salts or impurities (Straaten, 2002). The presence of magnesium is commonly associated with the occurrence of dolomite, $CaMg(CO_3)_2$, or with clay and magnesium-bearing minerals accompanying phosphate rocks. In addition, industrial additives or conditioning agents used during granulation and drying processes may contribute to magnesium levels. Some manufacturers may also incorporate small amounts of secondary nutrients to enhance the agronomic value or marketability of compound fertilizers (IFA, 2019).

In contrast, the presence of chloride may result from naturally occurring soluble salts within phosphate ores or from the use of industrial water and saline additives during manufacturing and granulation processes. Fertilizers may also be exposed to limited salt contamination during transportation and storage or through the use of anti-caking agents containing chloride compounds. Consequently, elevated chloride concentrations may reflect the nature of the raw materials or the efficiency of purification processes and may directly influence the electrical conductivity of the fertilizer (IFA, 2019).

The occurrence of potassium in DAP fertilizers can be explained by several chemical and industrial mechanisms. Some phosphate rocks contain silicate minerals or potassium feldspars associated with phosphate ore, resulting in the transfer of limited amounts of potassium to the final fertilizer product. In addition, certain manufacturing facilities utilize shared production lines for phosphate and potash fertilizers, which may lead to trace contamination of DAP with potassium compounds. Potassium-containing materials may also be added to improve the physical properties of fertilizer granules or enhance the fertilizing efficiency of certain compound fertilizer products (Becker, 1989; Ryszko et al., 2023).

From an agronomic perspective, the presence of these secondary elements is not necessarily undesirable and may increase the fertilizing value of the product when present in moderate concentrations. Calcium and magnesium are important secondary plant nutrients, while potassium plays a fundamental role in osmotic regulation, enzyme activation, and carbohydrate translocation within plants (Hasanuzzaman et al., 2018; Johnson et al., 2022). However, excessive levels of chloride or soluble salts may increase electrical conductivity and osmotic pressure, which can adversely affect plant growth, particularly in salt-sensitive crops and under arid soil conditions. This may adversely affect the growth of salt-sensitive plants, particularly in arid soils or soils with limited leaching capacity (Marschner, 2012).

The decomposition of organic matter leads to the formation of humic and fulvic substances as well as organic acids, which contribute to increasing cation exchange capacity, improving nutrient retention, and reducing nutrient losses through leaching or fixation (Stevenson & Cole, 1999; Lehmann & Kleber, 2015). In addition, organic matter forms chelated complexes with numerous nutrients, helping to maintain their availability and reduce their precipitation, particularly phosphorus in calcareous soils. Consequently, phosphorus in organic fertilizers tends to be more stable and less susceptible to fixation than phosphorus supplied through highly soluble mineral phosphate fertilizers (Jindo et al., 2023). The high solubility and nutrient retention efficiency of organic fertilizers can be attributed to the combined effects of organic compounds and microbial activity, both of which enhance nutrient dynamics within the soil.

From an environmental perspective, organic fertilizers are characterized by the gradual release of nutrients, which reduces nitrogen losses through leaching and volatilization while improving nutrient use efficiency over the long term (Diacono & Montemurro, 2010). Furthermore, the lower EC values of organic fertilizers decrease the likelihood of salt stress in plants compared with DAP fertilizers, which generally exhibit higher electrical conductivity. Organic fertilizers also play a crucial role in stimulating soil microorganisms and enhancing biological processes within the soil, thereby positively influencing mineralization rates and promoting the gradual and balanced release of nutrients (Lori et al., 2017). Moreover, organic matter contributes to improving soil structure, enhancing aggregate stability, increasing water-holding capacity, and improving soil aeration, characteristics that mineral fertilizers do not directly provide (Lehmann & Kleber, 2015). In contrast, DAP fertilizers are characterized by their rapid supply of nitrogen and phosphorus due to the fast dissolution and immediate release of nutrients. However, this rapid availability may be accompanied by increased risks of nutrient loss or chemical fixation, in addition to the potential for increased soil salinity when used intensively (Havlin et al., 2014).

4-Conclusion

This analytical study demonstrated substantial differences in the physicochemical characteristics and nutrient composition among the investigated fertilizer sources. The results confirmed that fertilizer origin and manufacturing processes significantly influence nutrient concentrations, ionic behavior, solubility, and chemical properties. Mineral DAP fertilizers exhibited higher electrical conductivity, total dissolved solids, and salt concentrations, reflecting their rapid nutrient release and immediate availability after dissolution. In contrast, the organic fertilizer was characterized by lower salinity, higher solubility and concentrations of nitrogen, phosphorus, and potassium, indicating its potential as a balanced and sustainable nutrient source. Among the mineral fertilizers, British DAP showed relatively higher nutrient concentrations, particularly phosphorus and nitrogen, whereas Saudi DAP exhibited the highest electrical conductivity and dissolved solids. The observed variations in calcium, magnesium, chloride, and potassium contents further emphasize the influence of phosphate rock quality, raw material composition, and industrial processing conditions on fertilizer characteristics. Overall, the findings highlight the importance of laboratory-based fertilizer evaluation as an effective tool for assessing fertilizer quality and predicting nutrient release behavior and potential impacts on soil chemical properties. The study suggests that integrating chemical characterization with nutrient composition assessment can provide valuable information for selecting suitable fertilizer sources and improving nutrient management strategies in agricultural systems.

Conflict of Interest

The authors declare that they have no conflict of interest.

Funding

This research received no external funding.

Data Availability

All data supporting the findings of this study are available within the manuscript.

Ethical Approval

This study did not involve human participants or animals. All experimental procedures were conducted in accordance with institutional and laboratory biosafety guidelines.

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