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Improving Potato Productivity through Innovative Fertilization Strategies under Drip Irrigation Conditions: A critical review

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ABSTRACT

This comprehensive research work focuses on the critical significance of potato cultivation and emphasizes the imperative to enhance its productivity using effective fertilization programs. In recent years, there has been a growing interest in enhancing the productivity of potatoes, to address the challenges posed by an escalating population and the cultivation of degraded soils. Researchers and policymakers are increasingly turning their attention to organic fertilization as a key approach to optimize potato tuber development. However, the lack of consensus among experts in the plant nutrition field regarding the best organic sources to use has sparked the need for comprehensive research and analysis. This review aims to address the knowledge gap by critically examining and synthesizing existing literature related to the impact of various organic sources on potato growth and tuber quality. Additionally, potassium (K) fertilization plays a crucial role in determining potato yield, and there is a lack of agreement on the most effective K sources to use. Therefore, this review will also explore the latest research on the influence of different K sources under fertigation systems on potato performance and productivity. Generally, this review article aims to identify significant hurdles and potential opportunities within the field, ultimately directing the course of future research directions and practical implementations. This review article h paves the way for enhanced crop productivity and improved food security while adhering to environmental sustainability principles**.**

INTRODUCTION

In developing countries like Egypt, one of the most significant challenges is optimizing the growth of strategic crops to achieve sustainable development in response to the pressing issues of escalating population growth and surging food demands **(Abo El-Ezz *et al.*, 2020; El-Hadidi *et al.*, 2020).**

This predicament is further accentuated by the need to address the widening disparity between these two factors. Optimizing the growth and productivity of strategic crops in Egypt is crucial for ensuring food security in the face of a rapidly growing population. By focusing on critical crops essential for sustenance and nutrition, the country can increase domestic production and reduce reliance on costly imports **(Soliman and El-Sherpiny, 2021).** This stabilizes food prices and availability and enhances the resilience of the agricultural sector against external shocks, such as fluctuations in global markets or climate-related challenges. Moreover, promoting the growth of strategic crops can stimulate rural economies, create employment opportunities, and improve the livelihoods of farmers, contributing to overall socioeconomic development and stability in the region (**Ghazi *et al.*, 2021).**

Potato (*Solanum tuberosum* L.) is considered a staple food for most of the world's population **(Ali *et al.*, 2021).** It occupies the fourth place after wheat, corn and rice, the first as the least expensive source of energy and the second in the production of proteins **(Naiem *et al.*, 2022).** Potato holds a crucial position as a strategic crop in Egypt due to its significance as a staple food source, providing a substantial portion of the daily caloric intake for the population. Its nutritional value and versatility contribute to dietary diversity, supplying essential vitamins, minerals, and carbohydrates. With the ability to thrive in various agro-climatic zones across Egypt, potatoes offer a reliable and accessible food source for both urban and rural communities. By reducing the country's dependence on imports and stabilizing domestic food prices, potato cultivation plays a vital role in ensuring food security. Additionally, the potato value chain creates employment opportunities and income for farmers, supporting rural development and contributing to the overall economic growth of the country **(El-Sherpiny *et al.*, 2022).** Organic fertilizations play a crucial role in raising the potato productivity by providing a balanced nutrient supply, improving soil health and fertility, suppressing diseases, promoting sustainability, and meeting market demands for high-quality produce **(Ghazi and El-Sherpiny, 2021).** Integrating organic fertilizers into potato cultivation practices can lead to improved yields, enhanced crop quality, and sustainable agricultural systems.

Organic fertilizers, such as compost, farmyard manure, chicken manure and other organic amendments, provide a slow-release and balanced supply of essential nutrients, including nitrogen (N), phosphorus (P), and potassium (K), as well as micronutrients **(Seadh *et al.*, 2021)**. These nutrients are crucial for various stages of potato growth, including root development, vegetative growth, flowering, and tuber formation. The gradual nutrient release from organic fertilizers ensures a sustained supply throughout the growing season, promoting optimal plant growth and maximizing yield potential **(Omar *et al.*, 2022)**. The significance of organic fertilization for potato tubers is widely recognized, yet the plant nutrition research community lacks a consensus regarding the optimal organic source for achieving this objective. Divergent opinions exist among researchers in this domain regarding the most suitable organic fertilizer (or source) for this purpose.

The role of potassium (K) is vital in the cultivation of potatoes as it influences various aspects of plant growth and development, ultimately impacting potato yield and quality (**El-Hadidi *et al.*, 2017)**. It has a so important role in sugar and starches formation in tuber crops because it enhances photosynthesis synthesis as well as it has the ability to transfer sugar and carbohydrate to the tubers. So the potato crop requires large amounts of potassium **(Ewais *et al.*, 2020).** While the crucial role of potassium (K) in regulating the development of potato tubers is well-established, there remains a lack of consensus within the scientific community regarding the most effective potassium source to be employed for this purpose **(Ghazi *et al.*, 2021)**. Choosing the best potassium source for potato cultivars should be based on soil testing and nutrient analysis to determine the specific potassium needs of the crop and the soil's existing nutrient levels. Proper and balanced potassium fertilization, combined with other essential nutrients, will help achieve optimal potato growth, higher yields, and improved tuber quality **(El-Sherpiny *et al.*, 2022).**

Drip irrigation is a highly efficient method of irrigation, as it can be particularly beneficial for potatoes grown on sandy or poor soils. Sandy soils have low water-holding capacity due to their coarse texture, making them prone to rapid drainage and water loss **(Abd-All *et al.*, 2017).** Drip irrigation delivers water directly to the root zone of plants, minimizing evaporation and runoff, thus conserving water. This is crucial in regions where water resources are limited or in areas facing water scarcity **(Feng *et al.*, 2017).** Also, sandy soils tend to leach nutrients quickly since they cannot retain them well. When traditional irrigation methods like flood irrigation are used, essential nutrients can be washed away from the root zone, leading to nutrient deficiencies for the potatoes **(Eissa, 2019).** Drip irrigation supplies water in a controlled manner, reducing leaching and helping to maintain optimal nutrient levels. Moreover, drip irrigation systems allow for precise water delivery, ensuring that each potato plant receives the right amount of water it needs. This targeted watering approach helps prevent under or overwatering, which can be common with other irrigation techniques **(Abdelraouf *et al.*, 2020).** Also, With drip irrigation, water is delivered directly to the root zone of the potato plants. This encourages deeper and stronger root development since the roots will naturally grow towards the water source. Improved root systems enable better nutrient and water uptake, leading to healthier and more productive potato crops **(Kaur *et al.*, 2022).**

In the pursuit of the study's goals, an extensive review of pertinent literature has been carried out, with a particular emphasis on the following crucial domains;

1. Drip Irrigation for Sandy Soils and Newly Reclaimed Areas

1.1. Natural of sandy soil and its suitability to plant growth

Sandy soils are identified by their composition, typically containing less than 18% clay and more than 68% sand within the top 100 cm of the soil profile. According to the World Reference Base (WRB) soil classification system, sandy soils are commonly found in Reference Soil Groups such as *Arenosols*, *Regosols*, *Leptosols*, and *Fluvisols* (**ISSS Working Group R.B. 1998a**). These soil types typically form in recently deposited sand materials like alluvium or dunes, exhibiting weak development and limited horizonation. Additionally, sandy soils with a high sand content within the top 100 cm can also be associated with the upper portion of extensively developed soils resulting from weathered quartz-rich materials or rocks, as indicated by the presence of highly depleted horizons (**Noble *et al.*, 2000**).Sandy soils are widely distributed across the globe, spanning over 900 million hectares. They are primarily found in arid and semi-arid regions. These soils have been recognized as naturally low in fertility, degraded, and exhibit poor physical, chemical, and biological characteristics (**Driessen *et al.*, 2001**). The physical properties of sandy soils are more complex than initially assumed. This complexity is particularly pronounced in tropical regions where sandy soils experience cycles of wetting and drying, which significantly impact their properties. Even slight variations in composition can result in substantial differences in physical characteristics. In general, sandy soils are characterized by the absence of a well-developed structure or the presence of a weakly developed structure (**Tayel *et al.*, 2001**). Arenosols, which encompass approximately 900 million hectares or 7% of the Earth's land area, present numerous challenges to agriculture, particularly in regions with seasonal hot and dry climates **(FAO, 2001).** Arenosols in warm climates typically exhibit reduced water and nutrient retention capacities due to their meager organic matter content and limited cation exchange capacity. These soils often offer a mere 50-110 mm of plant-available water per meter of soil. Furthermore, sandy soils in tropical regions are susceptible to rapid organic carbon depletion, largely driven by elevated soil temperatures **(Selim *et al.*, 2009).** The capacity of sandy soils to store carbon is generally less than 1%, largely attributed to their inability to shield carbon from microbial activity. In practice, actual soil carbon levels tend to be even lower due to reduced plant productivity and consequently, diminished carbon input rates. Farmers working with sandy soils must adopt meticulously designed, integrated water and nutrient management systems to boost productivity while simultaneously addressing concerns related to groundwater quality and soil acidity **(Sadek *et al.*, 2011).** Cultivated sandy soils often exhibit infertility, with their productivity being strongly influenced by the organic carbon content and moisture conditions. These soils possess characteristic properties such as low water-holding capacity, high permeability, and limited capacity to store or exchange nutrients. Their low silt, clay, and organic matter contents contribute to a weakly developed soil structure, rendering them susceptible to degradation processes. In situations where vegetation and the topsoil layer are removed, particularly during opencast mining activities, the decline in soil organic matter exacerbates challenges related to water and nutrient retention. These retention issues are crucial for supporting plant growth **(Xu *et al.*, 2013). El-Sherpiny, (2016)** reported that the productivity of sandy soils is primarily constrained by various agronomic challenges. Water availability, in particular, tends to be the limiting factor that determines the extent of cultivated areas. This is attributed to the extremely low specific surface area of sandy soils, which contributes to their chemically and biologically inert conditions. These soils exhibit very poor fertility levels in terms of their physico-bio-chemical properties, soil-water-plant relationships, and nutritional status. The limited presence of fine fractions, such as clay and organic matter, largely controls their overall fertility. **Kheir and Kamara, (2019)** reported that sandy soils and newly reclaimed soils face challenges such as poor water retention, low fertility, and subsequently low productivity. To address these issues, it is necessary to give more attention to maximizing their potential for water and nutrient supply by utilizing new and cost-effective soil conditioners. As reported by **Huang and Hartemink (2020),** sandy soils typically demonstrate low cation exchange capacity (CEC), base saturation, and overall fertility. Many of these attributes are intrinsic to the soils and are inherited from their parent materials. Just like with other soil types, the fertility of sandy soils is significantly affected by environmental factors, with soil organic matter (SOM) being a prominent factor.

1.2. Drip irrigation

Sandy soils pose unique challenges for agriculture due to their fast-draining nature and low water-holding capacity. However, employing drip irrigation systems can be a game-changer for farmers facing these challenges. Drip irrigation, also known as trickle or micro-irrigation, is a water-efficient method that delivers water directly to the plant's root zone in a slow and controlled manner **(Abd-All *et al.*, 2017).** One of the key benefits of drip irrigation in sandy soils is its ability to reduce water wastage. Sandy soils allow water to percolate quickly, leading to water runoff and inefficient water distribution when using traditional irrigation methods. With drip irrigation, water is delivered directly to the root zone, minimizing evaporation and ensuring that plants receive the necessary moisture to thrive, even in sandy soils **(Feng *et al.*, 2017).** Moreover, drip irrigation systems promote a more uniform distribution of water, preventing waterlogged areas and dry patches, which are common in sandy soils when using other irrigation methods. By providing a consistent water supply, the risk of plant stress and yield reduction is significantly reduced, resulting in healthier crops and better overall agricultural productivity **(Eissa, 2019).** Another advantage of drip irrigation in sandy soils is its ability to deliver fertilizers and other nutrients directly to the plant's roots. This targeted application enhances nutrient uptake efficiency and minimizes nutrient leaching into the groundwater. As sandy soils are more prone to nutrient leaching, drip irrigation becomes an invaluable tool in reducing environmental impacts and optimizing nutrient utilization **(Abdelraouf *et al.*, 2020).**In addition to water and nutrient conservation, drip irrigation systems can help in controlling weed growth and diseases. By delivering water directly to the plant roots and avoiding wetting the soil surface, weed seeds are less likely to germinate. Furthermore, since the foliage remains dry, the spread of certain plant diseases is curtailed, promoting healthier crops. However, successful implementation of drip irrigation in sandy soils requires careful planning and consideration of various factors. Farmers must assess the soil's water-holding capacity, the water requirements of the crops, and the optimal spacing and design of the drip lines. Additionally, regular maintenance and monitoring of the system are essential to ensure its proper functioning and efficiency **(Kaur *et al.*, 2022).**

2. Potato as a Strategic Crop in Egypt

Potato is considered a strategic crop in Egypt due to its importance as a major food crop, a source of income for farmers, and a significant contributor to the country's economy. Egypt is one of the world's top potato producers, with an annual production of around 4 million tons, and is the largest potato producer in Africa (**Abdrabbo *et al.*, 2010**). Potato is grown in different regions of Egypt, but the main potato-producing areas are located in the Nile Delta and the Nile Valley. The crop is usually grown as a winter crop, and the planting season starts in October and continues until January. The harvested potato tubers are used for both fresh consumption and processing into potato chips, French fries, and other potato products **(Rabia *et al.*, 2018**).The

Egyptian government has been making efforts to increase potato production and productivity to meet the growing demand for food due to the increasing population. This includes promoting the use of high-yielding potato varieties, improving farming practices, and investing in infrastructure and technologies for potato production **(Abd El-Hady *et al.*, 2021).** However, one of the challenges facing potato production in Egypt is the limited availability of fertile land, as much of the country's agricultural land is degraded or affected by salinity. This has led to a growing interest in the use of degraded soils for potato cultivation, which requires the application of appropriate soil management practices and the use of organic fertilizers to improve soil fertility and productivity **(Perez *et al.*, 2021**). Potatoes serve a variety of purposes, whether as a fresh vegetable, raw material for food processing, or as ingredients in different food products. They are also utilized for starch production, and can even be used as fodder for animals. From a nutritional standpoint, potatoes are an excellent source of energy and vitamins. They contain a high percentage of carbohydrates (19.4%) in the form of starch, along with protein (2%) and a small amount of fat (0.1%) (**Tantawy *et al.*, 2021).** Compared to cereal crops, potatoes have high digestibility of both starch and protein. While they lack vitamin A and vitamin E, they do contain a wide range of other vitamins, and significant amounts of vitamin B6 and vitamin C. Additionally, potatoes provide essential minerals like iron (Fe), calcium (Ca), phosphorus (P), magnesium (Mg), and sulfur (S) in sufficient quantities **(Awaad and Awaad, 2022).** The Food and Agriculture Organization (FAO) recommends a daily consumption of 125 – 150 grams of potatoes to fulfill vitamin requirements. Overall, potatoes offer a valuable and versatile nutritional resource that can play a significant role in meeting dietary needs (**El-Sherpiny *et al.*, (2022).**Overall, the strategic importance of potato in Egypt highlights the need for continuous research and development efforts to improve potato production, address challenges facing the crop, and promote sustainable potato farming practices (**Zhang *et al.*, (2022).**

3. The Debate in Potato Plant Nutrition Field

The debate in the potato plant nutrition field revolves around the effectiveness of different organic sources for potato production. While organic fertilization is known to be important for potato tubers, there is no consensus on the best organic source to use. Some researchers argue that composted plant residues or farmyard manure (FYM) are the most effective sources, while others suggest using chicken manure (ChM) or other animal-based fertilizers. The debate also extends to the best potassium source to use as a sizing agent for potato tubers. While potassium (K) is essential for potato growth and quality, there is no agreement on which potassium source is most effective. Some researchers recommend potassium nitrate or potassium citrate, while others argue for potassium silicate or potassium sulphate. Overall, the debate in the potato plant nutrition field highlights the complex interactions between different organic and inorganic fertilizers and their impact on potato growth and quality. It also underscores the importance of further research to identify the most effective and sustainable nutrient management practices for potato production.

3.1. Use of organic sources in potato production

Organic sources are an essential component of potato production. The use of organic sources such as compost, animal manure, and plant residues can improve soil fertility and crop productivity by providing essential plant nutrients, improving soil structure, increasing water-holding capacity, and reducing soil erosion. The use of organic sources can also improve soil health by increasing the population of beneficial soil microorganisms that promote nutrient cycling, disease suppression, and plant growth. Organic sources can also help to reduce the negative impact of chemical fertilizers on the environment by reducing nutrient leaching, soil acidification, and greenhouse gas emissions. However, the choice of organic source and its application rate should be based on the soil type, potato cultivar, and specific nutrient requirements of the crop. Over-application of organic sources can lead to nutrient imbalances, soil compaction, and waterlogging. In conclusion, the use of organic sources in potato production can lead to sustainable and environmentally friendly potato production systems that ensure high crop. **Mandic *et al.*, (2011)** assessed the impact of applying well-rotted farmyard manure on stem height and yield of potato plants. The findings indicated that well-rotted farmyard manure had the most significant effect, resulting in the highest increase in soil microorganism counts, potato yield, and stem height. This suggests that the application of well-rotted farmyard manure can effectively enhance soil microbial activity, leading to improved potato plant growth and productivity. **Moursy, (2013)** observed that the application of compost resulted in a notable increase in tuber potato production. Specifically, the tuber yield showed a significant increase when 50% compost was added along with 50% chemical fertilizer, in comparison to using 100% chemical fertilizer without any compost. These findings suggest that incorporating compost, as a partial substitute for chemical fertilizer can be an effective strategy to enhance tuber potato yield, demonstrating the potential benefits of integrating organic matter into the fertilization regime. **Sanli *et al.*, (2013)** conducted a study examining the impact of organic matter on potato yield and quality. They assessed seven different characteristics, which encompassed plant height, tuber count per plant, marketable tuber yield, total tuber yield, protein content, vitamin C content, and specific gravity. The findings revealed significant distinctions between the control group and the application of leonardite, a type of organic matter, across all the traits under investigation. The incorporation of organic matter resulted in remarkable enhancements, with a 22% surge in the number of tubers per plant, a 38% increase in marketable tuber yield, and a 15% rise in total tuber yield when compared to the control group. In a study by **Kahlel (2015),** the influence of organic fertilizers on potato performance was investigated. The results indicated that the utilization of poultry manure led to a noteworthy enhancement in several growth parameters. Notably, when compared to the control group, the potato plants treated with poultry manure exhibited significant increases in plant height, leaf area, fresh and dry weight, and the number of stems per plant. These outcomes suggest that the application of poultry manure as an organic fertilizer had a favorable impact on the overall growth performance of potato plants, pointing to its potential as a valuable and effective fertilizer choice for potato cultivation. **Abd El-Nabi *et al.*, (2016)** found that the use of compost was found to have a positive impact on potato growth, yield, and quality. Specifically, when compost was applied, it provided essential elements, enzymes, hormones, vitamins, and beneficial bacteria that play a role in nitrogen fixation and phosphorus solubilization. **Abd El-Hady *et al.*, (2021)** investigated the impact of organic fertilization, specifically compost and vermicompost, on various aspects of potato cultivation. The study focused on vegetative growth, the chemical composition of leaves, tuber yield, and tuber quality. The results showed that using compost led to significant improvements in the chemical composition of leaves and enhanced the quality of potato tubers. On the other hand, the application of vermicompost resulted in the highest values for potato growth parameters and overall tuber yield.

3.2. Overview of potassium fertilization on potato

Potassium (K) is one of the most essential macronutrients for potato tuber formation and growth. It plays a significant role in several physiological and biochemical processes that occur in the plant, such as osmoregulation, enzyme activation, and stomatal regulation. Potassium is also an essential element in sizing agents for potato tubers, which determines the market value of the crop. However, there is no consensus among plant nutrition researchers on the best potassium source that should be used for sizing agents. This review aims to provide an overview of the different potassium sources used in sizing agents for potato tubers and their effects on yield and quality **(Chen *et al.*, 2021).**

3.2.1. Potassium sources

Potassium nitrate (KNO_3) is one of the commonly used sources of potassium in sizing agents for potato tubers. It is a water-soluble salt that provides both K and nitrogen (N) to the plant. Several studies have shown that KNO_3 application increases the yield and quality of potato tubers. However, excessive use of KNO_3 can lead to a buildup of nitrate in the soil, which can cause environmental problems and affect the taste and quality of potato tubers **(Mghaiouini *et al.*, 2021).** Potassium sulphate (K_2SO_4) is another source of potassium used in sizing agents for potato tubers. It is a water-soluble salt that provides both K and sulfur (S) to the plant. The use of K_2SO_4 in potato production has shown to improve tuber yield and quality, particularly under low-S conditions. However, the application of K_2SO_4 can increase soil salinity levels, which can negatively affect soil fertility and plant growth **(Alla and Helmy, 2022).** Potassium citrate ($K_3C_6H_5O_7$) is a relatively low-cost source of potassium used in sizing agents for potato tubers. It is a water-soluble salt that provides both K and citrate to the plant. The use of $K_3C_6H_5O_7$ in potato production has shown to improve tuber yield and quality, particularly under low-pH conditions. However, its low solubility in water limits its use in fertigation systems **(Gowda *et al.,* 2022).** Potassium silicate (K_2SiO_3) is a relatively new source of potassium used in sizing agents for potato tubers. It is a water-soluble salt that provides K and silicon (Si) to the plant. The use of K_2SiO_3 in potato production has shown to increase tuber yield and quality, as well as improve plant resistance to abiotic and biotic stresses. However, its high cost compared to other potassium sources limits its use in potato production **(Oraee and Tehranifar, 2023).** In conclusion, the choice of potassium source for sizing agents in potato production depends on several factors, including soil type, pH, and nutrient availability. KNO_3, K_2SO_4, $K_3C_6H_5O_7$ and K_2SiO_3 are the commonly used potassium sources in potato production, and their use depends on the specific conditions of the potato growing region. However, further research is needed to determine the optimal rates and application methods of these potassium sources for improving potato yield and quality.

3.2.2. Effect of potassium on potatoes

According to **Trehan *et al.,* (2001),** the utilization of potassium had a range of beneficial effects on potato cultivation. Primarily, it contributed to an expanded leaf area and enhanced plant height. Moreover, increased levels of potassium were correlated with taller potato plants, greater chlorophyll content, larger leaf area, higher potassium concentration in the tubers, and elevated carbohydrate levels in the plants. **Adhikari and Karki (2006)** noted that the most effective means of increasing tuber size was through a higher potassium application rate, particularly at 100 kg K_2O ha^{-1}, as demonstrated in a field study conducted under semi-arid conditions with loamy sand soil. However, **Dkhil *et al.,* (2011)** found that the application of potassium nitrate (KNO3) did not result in increased tuber yield or tuber count, despite a significant increase in plant height, suggesting that the impact of KNO_3 on potato growth and yield might be influenced by specific environmental conditions and soil types. In a study by

Khan *et al.*, (2012), it was revealed that the application of potassium chloride (KCl) did not significantly affect the starch content of potato tubers, but it did enhance the chipping quality of the tubers in comparison to potassium sulfate (K_2SO_4). **Manolov *et al.*, (2015)** observed that potato tubers treated with potassium chloride (KCl) exhibited reduced vitamin C content when compared to both the control group and the sample treated with potassium sulfate (K_2SO_4). These findings suggest that KCl has an adverse impact on the vitamin C content in potato tubers. Even at the lowest KCl fertilization rate, which was 200 mg of potassium per kg of soil, the concentration of vitamin C in the potato tubers decreased by 46%. Proper and controlled use of potassium-based fertilizers, such as potassium sulfate, maybe a more suitable approach to maintaining higher vitamin C content in potatoes, ensuring better nutritional value in this essential vegetable crop. **Silva *et al.*, (2018)** conducted a study examining the impact of two potassium sources, chloride, and sulfate, on various aspects of potato chipping, specifically focusing on yield, specific gravity, and chip color. Their findings revealed that neither of the potassium sources had a significant effect on yield components, specific gravity, or chip color. In another study, **Ewais *et al.*, (2020)** investigated the influence of different potassium sources (control, potassium nitrate, potassium silicate, potassium humate, and mono potassium phosphate) on the yield and quality of the Spunta potato cultivar. The results showed that potato plants treated with potassium sources exhibited higher values for tuber number per plant, tuber weight per plant, total tuber yield, and marketable tuber yield in comparison to the control group. Furthermore, the potassium sources significantly impacted mineral nutrient levels (N, P, K, and B), total carbohydrates, specific gravity, and starch content in the tubers, surpassing the effects observed in the control treatment. Notably, among the various potassium treatments, potassium nitrate and potassium humate were particularly effective in enhancing both yield and yield components. In a study by **Ali *et al.*, (2021),** the effects of both soil and foliar application of potassium on the performance of potato plants were investigated. For soil application, potassium was introduced using the recommended dosage (RD) across all treatments, which entailed a combination of mineral fertilizers with K-feldspar and biofertilizers. In the case of foliar spraying, three potassium sources were employed: potassium citrate (PC), potassium silicate (PS), and monopotassium phosphate (MP). The findings revealed that the tallest plant height was observed in the treatment that utilized 100% mineral potassium fertilizer in conjunction with foliar application of MP. Furthermore, the phosphorus (P), potassium (K), and total carbohydrate content in the leaves showed significant increases with the same fertilization treatment. In terms of other growth parameters, the treatment combining mineral potassium fertilizer with foliar spraying of PC, regardless of the growing season, yielded the highest values for the number of stems, fresh and dry weight per plant, as well as nitrogen content in the leaves. **Tantawy *et al.*, (2021**) conducted a study to explore the impact of various organic and inorganic potassium sources, including potassium sulfate, potassium humate, potassium nitrate, and potassium silicate, on the growth and yield of potatoes, specifically the Cara cultivar. The results indicated that plants treated with potassium silicate exhibited the highest tuber count per plant. Furthermore, the texture of the tubers, and the levels of chlorophyll and carotene were significantly elevated when potassium humate and potassium silicate were employed as fertilizers for the Cara cultivar. Overall, the research highlighted that, among the potassium sources examined, potassium humate followed by potassium silicate had the most favorable influence on both the growth and quality of potatoes, emphasizing the potential advantages of using organic potassium sources like potassium humate and inorganic sources like potassium silicate to enhance the growth and quality of potatoes, particularly in the case of the Cara cultivar. In a study conducted by **El-Sherpiny *et al.*, (2022),** the impact of potassium (K) application at a rate of 750 mg K_2O L^{-1} using various K sources [control, potassium sulfate, potassium humate, potassium silicate, and potassium citrate] on the performance and yield quality of potato plants was assessed. The study results indicated that potato plants treated with potassium silicate displayed the highest level of performance and yield quality in comparison to those treated with other K sources. Conversely, the untreated plants (control) exhibited the lowest performance and yield quality. When ranked, potassium citrate secured the second position following potassium silicate, succeeded by potassium humate and then potassium sulfate.

3.3. Interaction between organic sources and potassium sources on potato

Ahamad *et al.*, (2014) evaluated assessed the impact of farmyard manure (FYM) in combination with or without potassium fertilizer application on potato yield. Their findings revealed that the yield was positively influenced by the addition of potassium fertilizer when used alongside FYM. The highest yield was observed when 100 kg of K_2O per hectare was applied in conjunction with 30 tons of FYM per hectare. Application of both FYM and K fertilizer resulted in a significant increase in both above-ground and tuber yields when compared to the control group.

Yazdanpanah and Motallebifard, (2017) explored the impacts of chicken manure and potassium fertilizer on potato yield and nutrient uptake. The chicken manure was applied at four different levels (0, 5, 10, and 15 T/ha), while potassium fertilizer, in the form of potassium sulfate, was administered at three different levels (0, 50, and 100 kg/ha). Their findings revealed that the highest tuber yield was achieved when chicken manure was applied at a rate of 15 tons/ha, in combination with potassium fertilizer at a rate of 100 kg/ha.

EL-Metwally *et al.*, (2023) assessed the impact of several interventions on the growth and yield quality of potato plants. The main factor under examination was the application of compost to the soil (applied or not). The sub-main factor was the use of potassium humate through fertigation (applied or not), and the sub-sub-main factor involved the foliar application of various mineral potassium sources, including potassium nitrate, potassium citrate, potassium silicate, and a control group. Among these interventions, it was found that the most successful approach involved applying compost in conjunction with the use of potassium humate, followed by the subsequent foliar spraying of potassium nitrate. This combined intervention significantly enhanced the growth performance and both the quantitative and qualitative yield of potato plants when compared to the other interventions studied.

4. Effect of Organic Sources on Soil Properties

Tejada *et al.*, (2006) observed that the inclusion of compost in the soil had the effect of expediting sodium leaching and diminishing electrical conductivity (EC). Consequently, this led to an augmentation in water-holding capacity and the stability of soil aggregates. In another study, **Agbede *et al.*, (2008)** investigated the consequences of applying poultry manure (PM) at a rate of 7.5 t/ha on sorghum cultivation. The findings revealed that PM application resulted in a decrease in soil bulk density and temperature, while concurrently enhancing soil porosity and moisture content. These alterations signify an enhancement in soil structure and its capacity to retain water. Additionally, the introduction of PM substantially raised the concentrations of soil organic matter and nutrients. This suggests that the manure played a significant role in elevating nutrient levels in the soil, which is advantageous for plant growth and overall productivity**. Ghulam *et al.*, (2011)** observed that the incorporation of compost into the soil resulted in significant enhancements in its chemical characteristics, particularly regarding pH, EC, and SAR, effectively bringing these properties to desired levels. Meanwhile, in a study by **Li et al. (2011**), the impact of modern intensive poultry litter (PL) on various soil physical and biological indicators of soil quality was assessed. Their findings revealed that amending the soil with PL led to an increase in the volumes of macropores and mesopores, while the volume of micropores decreased. This suggests that PL had a beneficial effect on the soil's pore structure, which could potentially improve water infiltration and aeration. Additionally, the tensile strength of the soil in the PL treatment was lower compared to using chemical fertilizer, indicating that PL contributed to better soil workability and reduced soil compaction. Moreover, the soil aggregate wet stability index was higher in the PL treatment compared to the use of chemical fertilizer, indicating that PL enhanced the stability of soil aggregates, which is crucial for erosion control and promoting soil structure**. Trupiano *et al.*, (2017)** conducted an evaluation of the effects of applying compost to soil. Their findings indicated that compost had a significant impact on improving soil fertility, primarily through the increase in total nitrogen and phosphorus contents. Additionally, the study suggested that compost application might also enhance and maintain soil biophysical characteristics. This implies that the use of compost can play a crucial role in promoting soil health and fertility by enriching nutrient levels and supporting favorable soil properties. **Mohamed *et al.*, (2020)** evaluated the influence of compost at 4.8, and 9.5 Mg ha^{-1} on various soil chemical and physical properties. The findings revealed that increasing the compost level had a positive effect on all studied soil properties and nutrient availability, except for soil salinity, which increased as the compost level increased. **Othman, (2021)** assessed the influence of different organic fertilizers, including farmyard manure, plant compost, and animal compost, on salt-affected soil properties. The results indicated that all organic fertilizers had a positive effect on soil available nutrients and electrical conductivity values compared to the control groups.

CONCLUSION

This comprehensive research underscores the paramount importance of potato cultivation and the need to maximize its productivity through modern approaches, particularly under drip irrigation systems and efficient fertilization programs. The multifaceted benefits of potatoes in global agriculture are evident, and the advanced methodologies explored in this study offer significant potential for optimizing yields. Emphasizing the incorporation of diverse organic fertilization sources and various potassium inputs as integral components of sustainable farming practices, the research paves the way for enhanced crop productivity and improved food security while adhering to environmental sustainability principles. In conclusion, the interaction effect between potassium fertilizer and organic amendments on potatoes refers to the combined impact of these two factors on the growth, development, and yield of potato plants.

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الملخص العربي

تحسين إنتاج البطاطس من خلال استراتيجيات التسميد المبتكرة تحت ظروف الري بالتنقيط

هذا العمل البحثي الشامل يركز على أهمية زراعة البطاطس ويؤكد على ضرورة زيادة إنتاجيتها من خلال برامج تسميد فعالة. في السنوات الأخيرة، كان هناك اهتمام متزايد بتعزيز إنتاجية البطاطس، لمواجهة التحديات التي يفرضها تزايد عدد السكان وحتمية زراعة الاراضي المتدهورة. يوجه الباحثون وصانعو السياسات اهتمامهم بشكل متزايد إلى الأسمدة العضوية باعتباره نهجًا رئيسيًا لتحسين تنمية درنات البطاطس. ومع ذلك، فإن عدم وجود إجماع بين الخبراء في مجال تغذية النبات بشأن أفضل المصادر العضوية للاستخدام أثار الحاجة إلى البحث والتحليل الشامل. تهدف هذه المراجعة إلى معالجة الفجوة المعرفية من خلال إجراء فحص نقدي وتجميع الدراسات السابقة المتعلقة بتأثير المصادر العضوية المختلفة على نمو البطاطس وجودة الدرنات. بالإضافة إلى ذلك، يلعب التسميد بالبوتاسيوم دورًا حاسمًا في تحديد إنتاجية البطاطس، وهناك عدم اتفاق على مصادر البوتاسيوم الأكثر فعالية للاستخدام. لذلك، سوف تستكشف هذه المراجعة أيضًا أحدث الأبحاث حول تأثير مصادر البوتاسيوم المختلفة في برامج التسميد على أداء البطاطس وإنتاجيتها. بشكل عام، يهدف هذا العمل إلى معرفة التحديات الكبيرة والفرص المحتملة في هذا المجال، موجهًا في النهاية مسارات البحث المستقبلية والتطبيقات العملية. يمهد هذا العمل الطريق لتعزيز إنتاجية المحاصيل وتحسين الأمن الغذائي مع الالتزام بمبادئ الاستدامة البيئية.