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Exploring the influence of supplemental potassium fertilizer types and rates on garlic quality and yield

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Abstract

Garlic farmers often seek strategies to improve yield and post-harvest storage longevity. This study investigated the impact of various supplemental potassium fertilizers on these parameters. The experiment, conducted in 2021 and 2022, utilized a randomized complete block design with seven treatments: two levels of potassium nitrate (2.5 and 5 g/L), two levels of potassium citrate (2.5 and 5 mL/L), two levels of potassium silicate (2.5 and 5 mL/L), and a control without fertilizer. The findings revealed a clear influence of supplemental potassium fertilization on several key aspects of garlic growth and quality. Applying potassium nitrate at 5 g/L consistently outperformed other treatments. Plants receiving this treatment grew taller (72.93 and 90.80 cm), boasted more leaves (9.20 and 12.03), and showcased the largest bulb diameter (5.40 and 5.21 cm) and highest number of cloves per bulb (14.60 and 14.30), ultimately translating to the highest total yield per feddan (feddan = 4200 m² = 0.420 hectares = 1.037 acres) (12.61 and 12.75 ton) in both seasons, respectively. Notably, this treatment also led to significantly higher chlorophyll content (78.67 and 73.45 SPAD unit) across both seasons, respectively, suggesting enhanced photosynthetic activity and improved plant health. Beyond these morphological features and yield benefits, the study explored the impact of supplemental potassium fertilizers on post-harvest storage quality – a crucial element for farmers aiming to minimize losses. The results were encouraging, indicating that supplemental potassium fertilization contributes to reduced post-harvest loss compared to the control. While all potassium treatments displayed positive effects, potassium silicate and potassium nitrate at 2.5 g/L offered the most significant reductions in percentage weight loss during both storage periods (one and two months after harvest). These findings highlight the importance of potassium management for optimizing garlic production and post-harvest handling, providing valuable insights for farmers and agricultural stakeholders seeking to maximize their yields and minimize losses.

Keywords: garlic quality, potassium citrate, potassium nitrate, potassium silicate, total chlorophyll, total yield.

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1. Introduction

Garlic represents a prominent member of the Allium vegetable family and ranks as the second most extensively cultivated winter crop, following onions (Diriba-Shiferaw *et al.*, 2015). Garlic is predominantly utilized for domestic consumption in various culinary applications, serving as both a seasoning and flavour enhancer (Sung *et al.*, 2014). Moreover, garlic is endowed with considerable therapeutic qualities and is utilized to address various health conditions including heart problems, digestive disorders, eye discomfort, and ear infections. This is due to its rich content of minerals, vitamins, and allicin (Elosta *et al.*, 2017). Garlic is considered a nutritious food that might also have antimicrobial characteristics. (Hernández-Montesinos *et al.*, 2023). The global price of garlic has been increasing during the COVID-19 pandemic. However, there is no evidence to suggest that consuming garlic provides protection against COVID-19. Garlic shows a high affinity for potassium (K) during its growth phases, absorbing significant quantities of nitrogen (N) and potassium (K), while its absorption of phosphorus (P) is comparatively modest(Wang *et al.*, 2022). Garlic necessitates a fertilizer with a composition characterized by higher levels of nitrogen (N) compared to potassium (K) and phosphorus (P), in a ratio of N:K:P of approximately 1:0.71:0.3 (Santos *et al.*, 2017). The cited ratio highlights a significant need for potassium (K), which is essential for boosting both the quantity and quality of garlic. K plays a vital role in facilitating the movement and dispersion of photosynthetic substances within the plant. Additionally, its contribution to enhancing crop resilience against unfavourable environmental factors emphasizes its significance in garlic farming (Wang *et al.*, 2020). In recent times, uneven application of nitrogen (N) and phosphorus (P) fertilizers has resulted to significant imbalances in the levels of nitrogen (N), phosphorus (P), and potassium (K) in the soil. Particularly in many regions of Egypt, there is an inadequate amount of potassium (K) in the soil (Gaballah *et al.*, 2020), leading to a decline in the quality of garlic, increased susceptibility to diseases and insect pests, and decreased yields (Wang *et al.*, 2022). Conversely, an abundance of potassium (K) can lead to decreased uptake and utilization of additional nutrients by crops. This encompasses a decline in the absorption of positively charged ions such as calcium, which can render crops more prone to lodging. Furthermore, decreased uptake of these ions reduces disease resistance, disturbs the soil's nutrient balance and structure, and may result in soil pollution (El-Nasr and Ibrahim, 2011). Research has painted a compelling picture of silicon's role in mitigating nutrient imbalances across various plant species (Kovács *et al.*, 2022). This versatile element tackles phosphorus (P) imbalances with a multi-pronged approach. In P-deficient conditions, it enhances P mobility and uptake through mechanisms like malate and citrate exudation, upregulation of P transporter genes, and reduced iron and manganese uptake (Kovács *et al*., 2022). For excess P, silicon forms apoplastic barriers in root cells and downregulates P transporter genes, preventing overload (Hu *et al*., 2020). Silicon's beneficial effects extend to other nutrient deficiencies. The effect of Silicon on maize and wheat increased chlorophyll content and nitrogen uptake, higher grain yields (Galindo *et al*., 2021), in rice balanced metabolite equilibrium, reduced stress hormones, growth promotion (Ali *et al*., 2020). Similarly, silicon treatment in magnesium-deficient maize maintains growth and enhances chlorophyll and soluble sugar content, while facilitating rapid recovery in zinc-deficient cucumber plants (Hosseini *et al*., 2019; Lozano-González *et al*., 2021). This research hypothesizes that applying different potassium sources (KNO_3, $K_3C_6H_5O_7$, K_2SiO_3) significantly affects the growth, yield, and quality of Sides 40 garlic variety in Egypt's Sohag governorate. The unique chemical properties of each source and their interactions with soil are expected to have distinct effects. The study aims to: 1) evaluate the impact of these sources on growth parameters like plant height, leaf number, and bulb diameter; 2) assess their influence on yield parameters like total and average bulb weight, and total yield; 3) analyze their effect on quality parameters like total soluble solids; and 4) identify the most suitable potassium source considering growth, yield, quality, and economic factors.

2. Materials and methods

2.1 Experimental site and treatments description

The experimental design employed a randomized complete block design (RCBD) with three replicates. The treatments for the experiment were: Potassium nitrate with two levels (2.5 and 5 g/L); potassium citrate with two levels (2.5 and 5 mL/L); potassium silicate with two levels (2.5 and 5 mL/L); and control treatment (without supplemental potassium fertilizer), in total 7 treatments. The field experiments were conducted during the winter seasons of 2020/2021 and 2021/2022 at a private farm located in Juhaynah city, Sohag Governorate, Egypt, with coordinates approximately 23°40'26" north latitude and 51°29'31" east longitude. The experimental plots, each measuring 3 meters in width and 3.5 meters in length (10.5 square meters in total), underwent soil sterilization before planting using agricultural sulfur from Abu Qir Fertilizer and Chemical Industries at a rate of 100 kilograms per feddan (equivalent to 4200 square meters). The recommended basal dose of P_2O_5, totalling 60 kilograms per feddan, with a composition of 15.5% $CaH_6O_9P_2$, was incorporated into the soil, along with 20 cubic meters of decomposed organic fertilizer. Nitrogen fertilization consisted of 120 kilograms per feddan of NH_4NO_3 (33.5% N) and 48 kilograms per feddan of

K_2O (50% potassium sulfate), divided into two equal splits applied at 30 and 60 days after planting, following the guidelines of the Ministry of Agriculture, Egypt (Hassan, 2011). Garlic cloves, variety Sides 40, were obtained from Agricultural Research Center, Giza governorate, Egypt. Then the land was plowed in two perpendicular plows, planning at a rate of 12 lines for each two stalks, and planting on both sides of the line. Garlic cloves were planted manually at a distance of 10 cm between the hills on September 20, 2020, and 2021. The plants were sprayed four times after 35 days of planting, with a 15-day interval between them.

2.2 Morphological and yield measurements

During the harvest stage, plant samples were gathered on 28th March 2021, growing season, and 2nd April 2022 growing season. Morphological measurements were taken from 5 plants from each replicate and yield measurements were taken for each treatment after harvesting. Morphological measurements include the length of the plant from the bottom of the plant to the top leaf plant (cm); the number of leaves per plant; the diameter of the neck of the bulb; the diameter of the bulb; and Neck-to-bulb diameter ratio (neck diameter ÷ bulb diameter). Yield measurements included: weight of garlic bulb in grams (average of 5 plants); number of cloves per head of garlic; and total fresh yield per feddan (tons /feddan).

2.3 Total chlorophyll (SPAD)

The chlorophyll contents of fully developed leaves were assessed using a mobile chlorophyll meter (SPAD-502-m by Konica Minolta, Inc., Tokyo, Japan). Prior to taking the readings, the chlorophyll meter was calibrated following the manufacturer's instructions. After 120 days of planting, 30 readings were taken for each treatment (10 readings on old leaves, 10 readings on medium leaves, and 10 readings on young developed leaves) and then their average was recorded.

2.4 Storage quality

To calculate the percentage of loss in yield weight after harvest, a sample with a known weight was taken for each treatment, then the weight was recorded after two storage periods (one month after harvest and two months after harvest). The percentage of loss was calculated with the following equation :

1 -Percentage of weight loss after first storage (%) = (Sample weight after one month / Sample weight after harvest) × 10.

2- Percentage of weight loss after storage second (%) = (Sample weight after two months/Sample weight after harvest) × 100.

2.5 Statistical analysis

The data collected from these experiments underwent statistical analysis using Statistix 8.1 software. One-way ANOVA (Analysis of variance) was utilized to assess the significance of treatment effects on growth parameters and yield data. To further investigate and compare the means that exhibited significant differences, the Least Significant Difference (LSD) test was employed. These tests enable a thorough examination of the variations between treatment means with a confidence level of 95% (Gomez and Gomez, 1984).

3. Results

3.1 Morphological traits

Supplemental potassium fertilizers had a positive effect on morphological traits of garlic plants (Figure 1, 2, 3, 4, and 5). The plants given PN at a rate of 5 g/L were the tallest (72.93 cm), with significant differences between them and the rest of the treatments other than PN at a rate of 2.5 g/L and PS at a rate of 2.5 mL/L during the first season 2020/2021 (as shown in Figure 1 A), while the plants were the shortest in the control treatment (61.60 cm). The plants given PN at a rate of 5 g/L were the tallest (90.80 cm), with significant differences among other treatments during the second season of 2021/2022 while the plants were the shortest in the control treatment (65.80 cm) (Figure 1 B).

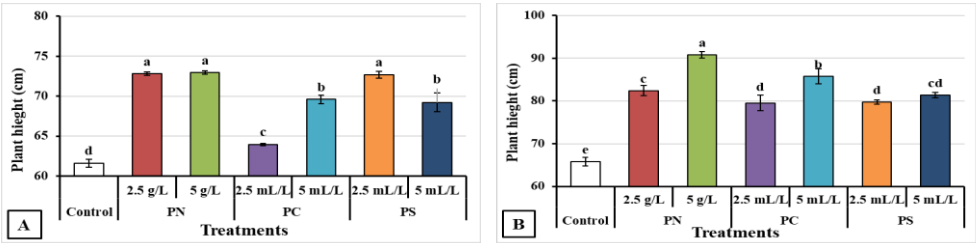

Figure (1): Effect of potassium fertilizer types and rates on plant height (cm) of garlic plants during the 2020/2021 (A) and 2021/2022 (B) growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of *p=0.05*, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

Plants treated with PN at 5 g/L produced the most leaves throughout both growing seasons (2021 and 2022), with a significant difference compared to other treatments (Figure 2 A and B). Notably, these plants had 9.20 and 12.03 leaves in 2021 and 2022, respectively. In contrast, plants in the control group had the fewest leaves, with only 8.20 and 9.53 leaves in 2021 and 2022, respectively. Plants treated with PC at a rate of 2.5 mL/L produced the largest onion neck diameter (2.25 cm) during the first growing season, followed by the PN treatment at a rate of 5 g/L (2.19 cm), with no significant difference with the rest of the other treatments except the control treatment (1.70 cm) (Figure 3 A). In the case of the second season, the largest diameter of the onion neck was under the PN treatment at a rate of 5 g/L (2.42 cm) with significant difference among other treatments, followed by the PC treatment at a rate of 5 mL/L (2.24 cm) (Figure 3 B). In contrast, the control group plants had the lowest bulb neck diameter, with only 1.70 and 1.46 cm in both the first and second seasons, respectively.

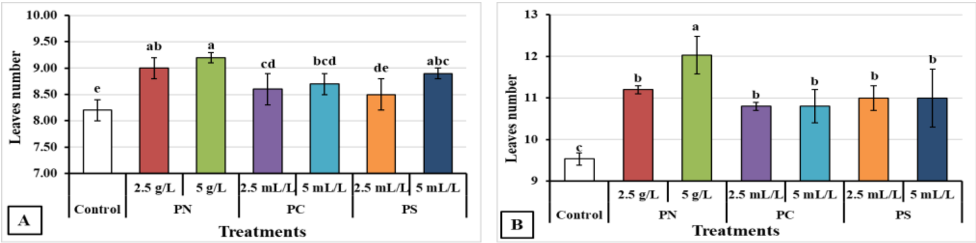

Figure (2): Effect of potassium fertilizer types and rates on leaves number of garlic plants during the 2020/2021 (A) and 2021/2022 (B) growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of p=0.05, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

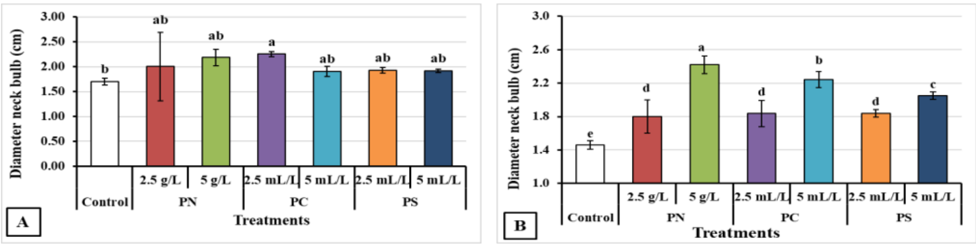

Figure (3): Effect of potassium fertilizer types and rates on diameter neck bulb (cm) of garlic plants during the 2020/2021 (A) and 2021/2022 (B) growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of p=0.05, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

Plants treated with PN at a rate of 5 g/L produced the largest onion diameter (5.40 cm) during the first growing season, followed by the PC treatment at a rate of 5 mL/L (5.13 cm), with significant difference among other treatments (Figure 4 A). In the case of the second season, the largest diameter of the onion was under the PS treatment at a rate of 2.5 mL/L (5.64 cm) with significant difference among other treatments, followed by the PS treatment at a rate of 5 mL/L (5.24 cm) (Figure 4 B). In contrast, the control group plants had the lowest bulb diameter, with only 4.83 and 3.62 cm in both the first and second seasons, respectively.

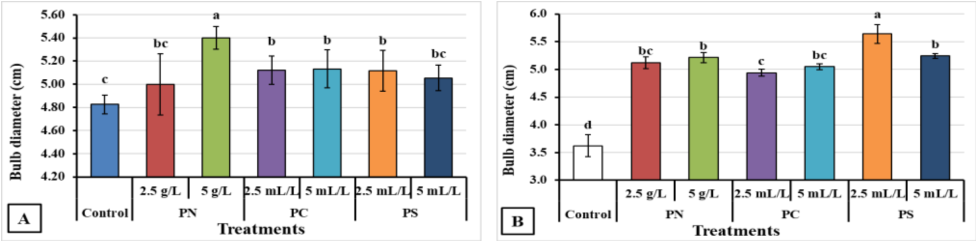

Figure (4): Effect of potassium fertilizer types and rates on bulb diameter (cm) of garlic plants during the 2020/2021 (A) and 2021/2022 (B) growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of p=0.05, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

Plants treated with PC at a rate of 2.5 mL/L were given the largest neck-to-bulb diameter ratio (0.44) during the first growing season, followed by the PN treatment at a rate of 5g/L (0.40), with no significant difference among other treatments (Figure 5 A). In the case of the second season, the largest neck-to-bulb diameter ratio was under the PC treatment at a rate of 2.5 mL/L (0.44) with a significant difference among other treatments, followed by the PN treatment at a rate of 5 g/L (0.44) (Figure 5 B).

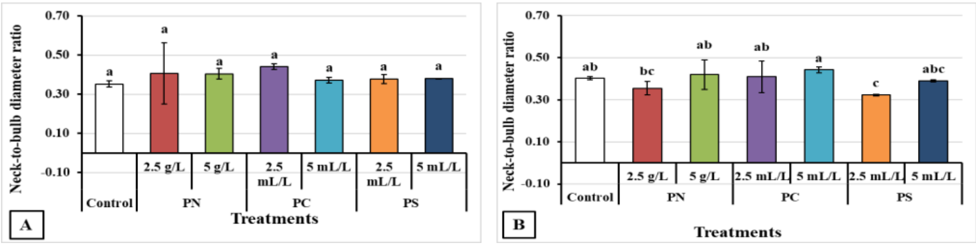

Figure (5): Effect of potassium fertilizer types and rates on neck-to-bulb diameter ratio of garlic plants during the 2020/2021 (A) and 2021/2022 (B) growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of p=0.05, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

3.2 Yield traits

Supplemental Potassium fertilizers had a positive effect on yield traits of garlic plants (Figure 6, 7, and 8). Plants treated with PN at a rate of 5 g/L were given the largest number of cloves per bulb (14.60) during the first growing season, followed by the PN treatment at a rate of 2.5 g/L (13.00), with significant difference among other treatments (Figure 6 A). In the case of the second season, the largest number of cloves per bulb was under the PN treatment at a rate of 2.5 g/L (14.70) with a significant difference among other treatments, followed by the PN treatment at a rate of 5 g/L (14.30) (Figure 6 B). In contrast, the control group plants had the lowest number of cloves per bulb, with only 11.10 and 13.00 in both the first and second seasons, respectively.

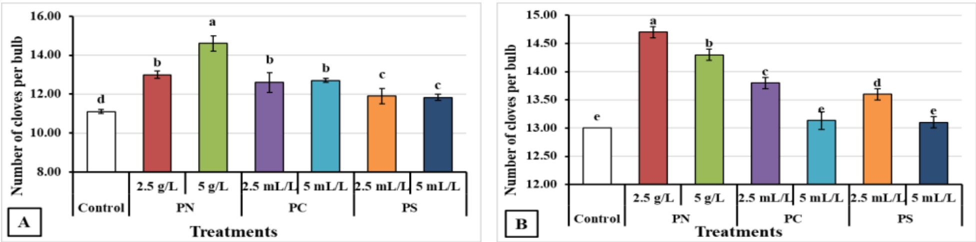

Figure (6): Effect of potassium fertilizer types and rates on number of cloves per bulb of garlic plants during the 2020/2021 (A) and 2021/2022 (B) growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of p=0.05, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

Plants treated with PN at a rate of 5 g/L were given the heaviest bulb weight (98.50 g) during the first growing season, followed by the PN treatment at a rate of 2.5 g/L (97.97 g), with significant difference among other treatments (Figure 7 A). In the case of the second season, the heaviest bulb weight was under the PN treatment at a rate of 5 g/L (99.60 g) with a significant difference among other treatments, followed by the PN treatment at a rate of 2.5 g/L (97.30 g) (Figure 7 B). In contrast, the control group plants had the lighter bulb weight, with only 77.00and 74.00 g in both the first and second seasons, respectively. Plants treated with PN at a rate of 5 g/L were given the largest total yield per feddan (12.61 ton/feddan) during the first growing season, followed by the PN treatment at a rate of 2.5 g/L (12.54 ton/feddan), with significant difference among other treatments (Figure 8 A). In the case of the second season, the largest total yield per feddan was under the PN treatment at a rate of 5 g/L (12.75

ton/feddan) with a significant difference among other treatments, followed by the PN treatment at a rate of 2.5 g/L (12.45 ton/feddan) (Figure 8 B). In contrast, the control group plants had the lowest total yield per feddan, with only 9.86 and 9.47 ton/feddan in both the first and second seasons, respectively.

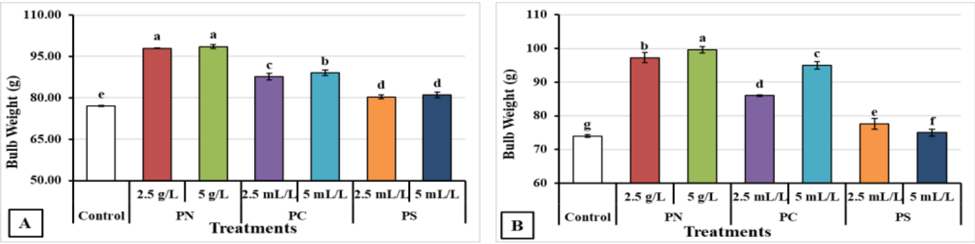

Figure (7): Effect of potassium fertilizer types and rates on bulb weight (g) of garlic plants during the 2020/2021 (A) and 2021/2022 (B) growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of p=0.05, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

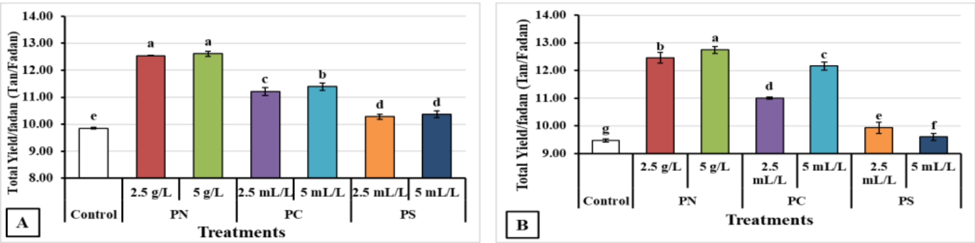

Figure (8): Effect of potassium fertilizer types and rates on total yield per feddan (tan/feddan) of garlic plants during the 2020/2021 (A) and 2021/2022 (B) growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of p=0.05, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

3.3 Total chlorophyll

Supplemental Potassium fertilizers had a positive effect on total chlorophyll characteristics in garlic crops (Figure 9). Across both growing seasons, plants given PN at 5g/L had the highest levels of chlorophyll content (78.67mg and 73.45 SPAD unit in first and second growing seasons, respectively), compared to all other treatments (as shown in Figure 9 A and B). In contrast, the control group had the lowest chlorophyll content in both seasons (65.97 SPAD unit in first and second growing seasons, respectively).

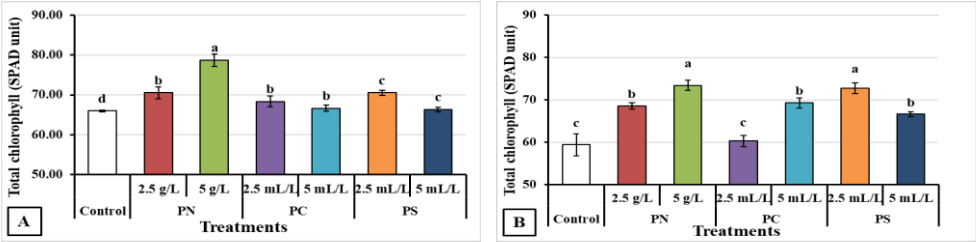

Figure (9): Effect of potassium fertilizer types and rates on total chlorophyll (SPAD unit) of garlic plants during the 2020/2021 (A) and 2021/2022 (B) growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of p=0.05, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

3.4 Storage quality

Supplemental Potassium fertilizers had a positive effect on storage characteristics and reduced the percentage of post-harvest loss in garlic crops (Figure 10 A, B, C, and D). In the first season, the lowest percentage of loss after harvest was during the first storage period (one month after harvest) under the treatment of potassium silicate at a rate of 5 mL/L (47.10 %) followed by potassium citrate at a rate of 5 mL/L (49.10 %) with significant differences between the treatments, and the highest percentage of post-harvest loss under the control treatment was (54.90 %) (Figure 10 A). While in the second season, the lowest percentage of post-harvest loss was during the first storage period (one month after harvest) under the potassium nitrate treatment at a rate of 2.5 g/L (46.50 %), followed by potassium citrate at a rate of 2.5 mL/L (50.60 %), with significant differences between the treatments. The highest percentage of loss after harvest was under the control treatment (67.20 %) (Figure 10 B). In second storage period (two months after harvest), the lowest percentage of loss after harvest was during the first season under the treatment of potassium silicate at a rate of 2.5 mL/L (14.00 %) followed by potassium silicate at a rate of 2.5 mL/L (15.00%) with significant differences among other the treatments, and the highest percentage of post-harvest loss under the control treatment was (21.50 %) (Figure 10 C). While in the second season, the lowest percentage of post-harvest loss was during the second storage period (two month after harvest) under the potassium silicate treatment at a rate of 5 mL/L (16.70 %), followed by potassium nitrate at a rate of 2.5 g/L (19.00 %), with significant differences between the treatments. The highest percentage of loss after harvest was under the control treatment (30.70 %) (Figure 10 D).

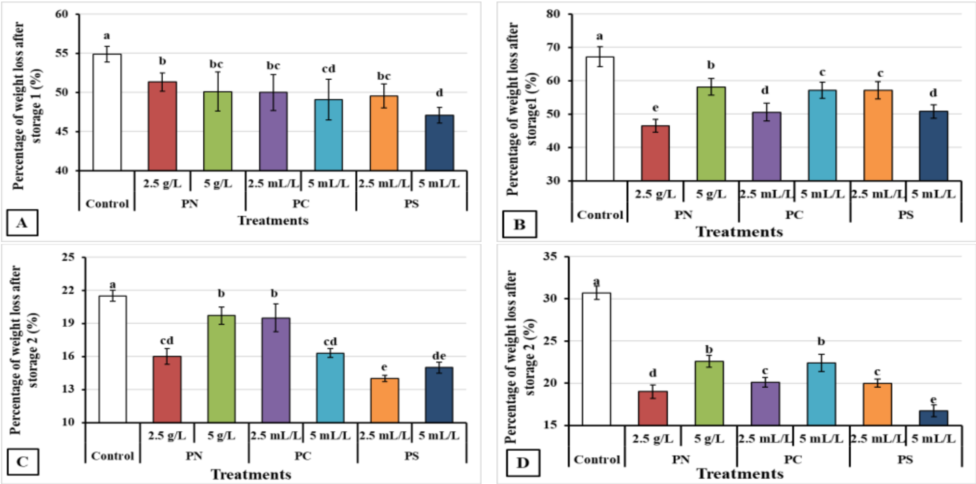

Figure (10): Effect of potassium fertilizer types and rates on the percentage of weight loss in garlic plants after one month (2020/2021 A, 2021/2022 B) and two months (2020/2021 C, 2021/2022 D) during the respective growing seasons. Values are means ± standard deviations (SDs) of data obtained from three biological replicates (n=3). Following the application of Duncan's multiple range test at a significance level of p=0.05, it was observed that means within the same column that share identical letters were not significantly different from each other. Where: PN= potassium nitrate; PC= potassium citrate; PS= potassium silicate.

4. Discussion

The effects of various types and quantities of additional potassium supplemental fertilizers on garlic crop yields and quality were investigated. As garlic is particularly responsive to potassium, applying potassium supplemental fertilizer can enhance the assimilation of carbon and nitrogen in garlic plants, facilitating the movement of assimilated nutrients from the leaves above ground to the bulbs below ground (Xu *et al*., 2024a; 2024b). Consistently applying potassium nitrate (PN) at a concentration of 5 g/L consistently resulted in the most notable enhancements across multiple parameters. Plants treated with this concentration demonstrated heightened plant height, increased leaf count, larger bulb diameter, higher number of cloves per bulb, and greater total yield per feddan compared to alternative treatments. This consistent performance underscores the potential of PN as a highly effective fertilizer for garlic cultivation. On the other hand, a lack of potassium adversely affects the growth and expansion of garlic leaves, resulting in hindered development and stunted growth (El-Mageed *et al*., 2023). Indeed, nitrogen plays a pivotal role in plants as it is utilized for the synthesis of crucial components such as amino acids, chlorophyll, enzymes, and DNA (Stein and Klotz, 2016). On the flip side, potassium plays a vital role in activating enzymes, synthesizing ATP (which is crucial for energy production), and regulating stomatal opening and closure in plants (Hawrylak-Nowak *et al*., 2018). Both nitrogen and potassium are indispensable nutrients crucial for the robust growth and proper functioning of plants. Promoting the absorption of nitrogen and potassium in plants has a positive impact on biomass accumulation. Research has shown that when plants receive increased potassium levels in conjunction with a steady nitrogen supply, it leads to increased plant photosynthesis, stomatal conductance, transpiration, and ultimately, improved biomass accumulation (Guo *et al*., 2019). On the contrary, when the supply of potassium is decreased while maintaining the same level of nitrogen, these processes are adversely impacted (Guo *et al*., 2019). In initial sequential studies, the efficacy of potassium in facilitating nitrate absorption, root-to-shoot translocation, and plant assimilation was evidenced. Notably, a greater potassium provision was observed to elevate shoot nitrate concentration and augment nitrate reductase activity (Xu *et al*., 2024a). Simultaneously, the supply of nitrate also promotes the absorption and assimilation of potassium, especially in the presence of light (Blevins *et al*., 1974). All treatments involving potassium nitrate (PN), particularly the concentration of 5 g/L, resulted in notably higher chlorophyll content during both seasons, suggesting enhanced photosynthetic activity and potentially enhanced plant health. Research has shown that foliar application of potassium fertilizer has the ability to enhance crop yield and overall plant biomass, especially in stressful conditions (Amanullah *et al*., 2016). However, the exact relationship between foliar-applied potassium fertilizer and nitrogen uptake remains unclear. Field application of potassium fertilizer has been shown to have positive effects on plant vitality and productivity. It improves various aspects including SPAD (chlorophyll content), photosynthesis, transpiration, and fruit yield (Yang *et al*., 2017). One function of potassium metabolism is to facilitate the efficient transport of photosynthates in the phloem by stimulating ATP production, thus supporting positive transportation (Haddad *et al*., 2016). The heightened ATP production facilitates the transfer of photosynthates from source organs (e.g., leaves) to sink organs (e.g., fruits), as proposed by Kirkby *et al*. (2023). This process likely contributed to the enhanced overall performance and bulb yield observed in our experiment. Overall, this study presents compelling evidence for the beneficial effects of supplemental potassium fertilization, especially using PN at a concentration of 5 g/L, on different aspects of garlic production and storage. Further research focusing on specific mechanisms, economic feasibility, and comparisons with alternative fertilizers will help refine and optimize potassium management strategies for garlic growers.

5. Conclusion

This two-season field study revealed a significant impact of supplemental potassium fertilizers on various aspects of garlic growth and quality. Application of potassium nitrate at 5 g/L emerged as the most effective treatment, consistently promoting superior plant morphology, yield, and chlorophyll content compared to other treatments. The observed increases in plant height, leaf number, bulb diameter, and clove number ultimately translated to the highest total yield per feddan in both seasons. Moreover, this treatment demonstrably enhanced photosynthetic activity through significantly higher chlorophyll content across both growing seasons. Beyond these direct agronomic benefits, the study demonstrated the positive influence of potassium fertilizers on post-harvest storage quality – a crucial factor for garlic growers seeking to minimize losses. While all potassium treatments displayed improved storage quality compared to the control, potassium silicate and potassium nitrate at 2.5 g/L offered the most significant reductions in weight loss during both storage periods. In conclusion, this study conclusively highlights the potential of potassium management for optimizing garlic production and post-harvest handling. Potassium nitrate at 5 g/L emerged as the most effective treatment, demonstrating significant improvements in multiple key areas. Additionally, potassium silicate showed promise for enhancing storage quality, suggesting its potential as a complementary practice. These findings contribute valuable insights for farmers and agricultural stakeholders seeking to maximize garlic yields and minimize losses, ultimately contributing to improved economic returns and food security.

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