Revista de Ciências Agroambientais

Agronomia **DOI:** 10.30681/rcaa.v23i1.13288

African scarlet garden egg performance and soil microbial population as affected by muriate of potash application

Tajudeen Bamidele Akinrinola[1,*], Olufunto Taiwo Adedokun[1], Adewale Mubo Omogoye[1] and Olajire Fagbola[2]

[1] Department of Crop and Horticultural Sciences, Faculty of Agriculture, University of Ibadan, Ibadan, Nigeria.
[2] Department of Soil Resources Management, Faculty of Agriculture, University of Ibadan, Ibadan, Nigeria.

* Autor Correspondente: tb.akinrinola@gmail.com

Recebido: 10/01/2025; Aceito: 25/04/2025.

Abstract: Intensifying land use for garden egg cultivation to meet the nutritional needs of the increasing population resulted in crop yield decline over time when nutrients removed through crop harvest and erosion are not replenished. In resolving deficiencies such as K in the soil, there is a shortage of information on their effect on associated soil microbial changes. Therefore, this study investigates the impact of muriate of potash (MOP) on garden egg growth and changes in microbial population. Using 10 kg soil in a repeated screenhouse experiment, MOP at 0, 15, 30, and 45 kg K_2O ha^{-1} were evaluated in a completely randomised design with four replicates. Data collected on growth and yield parameters were subjected to analysis of variance using SAS software version 9.0. The significantly different means were separated using LSD at $p<0,05$ probability level. Plant height, number of leaves, and leaf area were similar among treatments during the first and second plantings, but the values were optimum at 25 and 30 kg K_2O ha^{-1} of MOP, respectively. The dry shoot weight differed significantly among the treatments and ranged from 70,13 to 81,63 and 84,61 to 253,85 g plant^{-1} with the optimum values at 14.53 and 16.60 kg K_2O ha^{-1} of MOP during the first and second plantings, respectively. However, the fruit yields were significantly different among the treatments with the optimum yields observed at 30.81 and 23.05 kg K_2O ha^{-1} of MOP in the first and second plantings, while 15 and 45 kg K_2O ha^{-1} treatments had similar yields during both plantings. The negative regression curves equations indicated that a higher K application of 45 kg K_2O ha^{-1}, garden eggs' dry shoot weight and fruit yield decreased. During the two plantings, the garden egg plants encouraged bacterial and fungal colonies more than those observed before planting. Bacterial and fungal colonies were optimal at 25.29 and 26.75, and 33.85 and 23.25 kg K_2O ha^{-1} with significantly high R^2 values during the first and second plantings, respectively. Due to environmetal cost, applying MOP at 25 kg K_2O ha^{-1} was considered most appropriate for optimum garden egg yield.

Key-words: soil microbial communities, potassium fertiliser, *Solanum aethiopicum* gr. Gilo (L), soil improvement.

Desempenho do ovo de jardim escarlet africano e população microbiana do solo afetada pela aplicação de muriato de potassio

Resumo: A intensificação do uso da terra para o cultivo de ovos de jardim para atender às necessidades nutricionais da população crescente resultou no declínio do rendimento das culturas ao longo do tempo, quando os nutrientes removidos através da colheita e erosão não são reabastecidos. Na resolução de deficiências como o K no solo, há uma escassez de informação sobre o seu efeito nas alterações microbianas associadas ao solo. Portanto, este estudo investiga o impacto do muriato de potássio (MOP) no crescimento de ovos de jardim e alterações na população microbiana. Utilizando 10 kg de solo em um experimento repetido, MOP em 0, 15, 30 e 45 kg K_2O ha^{-1} foram avaliados em delineamento inteiramente casualizado com quatro repetições. Os dados coletados sobre os parâmetros de crescimento e rendimento foram submetidos à análise de variância utilizando o software SAS versão 9.0. As médias significativamente diferentes foram separadas usando LSD no nível de probabilidade $p<0,05$. A altura da planta, o número de folhas e a área foliar foram semelhantes entre os tratamentos durante o primeiro e segundo plantio, mas os valores foram ótimos em 25 e 30 kg K_2O ha^{-1} de MOP, respectivamente. O peso da parte aérea seca diferiu significativamente entre os tratamentos e variou de 70,13 a

81,63 e 84,61 a 253,85 g planta^{-1} com os valores de optmum em 14,53 e 16,60 kg K_2O ha^{-1} de MOP durante o primeiro e segundo plantios, respectivamente. No entanto, as produtividades de frutos foram significativamente diferentes entre os tratamentos, com as produtividades ótimas observadas em 30,81 e 23,05 kg K_2O ha^{-1} de MOP no primeiro e segundo plantios, enquanto os tratamentos de 15 e 45 kg K_2O ha^{-1} apresentaram produtividades semelhantes durante ambos os plantios. As equações das curvas de regressão negativas indicaram que uma maior aplicação de K de 45 kg K_2O ha^{-1}, peso da parte aérea seca dos ovos de jardim e rendimento de frutos diminuiu. Durante as duas plantações, as ovoplantas de jardim incentivaram mais as colônias bacterianas e fúngicas do que as observadas antes do plantio.colônias bacterianas e fúngicas mais do que as observadas antes do plantio. As colônias bacterianas e fúngicas foram ótimas em 25,29 e 26,75 e 33,85 e 23,25 kg K_2O ha^{-1} com valores de R^2 significativamente altos durante o primeiro e segundo plantios, respectivamente. Devido ao custo ambiental, a aplicação de MOP a 25 kg K_2O ha^{-1} foi considerada a mais adequada para uma ótima produção de ovos de jardim.

Palavras chave: comunidades microbianas do solo, aplicação de potássio, *Solanum aethiopicum* gr. Gilo (L), melhoria do solo.

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1. INTRODUCTION

Garden eggs, also known as *Solanum aethiopicum* gr. Gilo (L) are a popular vegetable crop cultivated extensively in various regions worldwide, particularly in sub-Saharan Africa (MAUNDU et al., 2009; PLAZAS et al., 2014). These crops play a crucial role in food security and livelihood for many smallholder farmers. The increase in population and the attempt to satisfy the populace's needs have put more pressure on the available land resources for crop cultivation (AKPAN & EBONG, 2021). The intensification of cultivation on the limited available land consistently removes nutrients from the soil as yield (KOPITTKE et al., 2019). The removal of nutrients without adequate replenishment strategies limits yield. The average world yield of garden eggs in 2021 and 2022 rose from 29957,4 to 31335,9 kg ha^{-1}, while in Africa, the yield decreased from 20431,7 to 20037,9 kg ha^{-1}, respectively (FAO, 2024). Aside from poor genetic materials, the reduction in garden egg yield in Africa is mainly due to poor soil nutrient management (STEWART et al., 2019). Soil fertility maintenance practices significantly influenced the productivity of garden eggs (ADJEI et al., 2023). Consequently, crop yield declines gradually over time when adequate measures are not employed to replenish the depleted nutrients. The soil microbial communities are also affected, leading to poor soil health that further impacts crop yield (USERO et al., 2021).

Soil fertility depletion has been identified as a major constraint to agricultural productivity in sub-Saharan Africa (KOPITTKE et al., 2019). Crop yield reduction due to low fertility status is more prominent when macronutrients (N, P and K) are involved (ADEKIYA et al., 2023). Most soil amendments for enhanced crop performance in tropical and subtropical areas have focused on N, P and organic matter, with minimal attention on K (ADEKIYA et al., 2023; MATISIC et al., 2024). This was probably due to it not being included in the plant's metabolic pathways like N and P or the high K content in the soil parent material (SARDANS & PEÑUELAS, 2021). However, K is the second most abundant element in the leaf biomass, substantiating the relevance of the nutrient element in the plant's physiological processes. The intensive cultivation of fruit and vegetables, such as garden eggs with high K demand, has resulted in the continuous mining of the nutrients from the soil (SARDANS & PEÑUELAS, 2021). Therefore, the decline in crop yield is also caused by a deficiency in K nutrition, aside from the low N and P or poor soil organic matter content commonly reported. The current inconsistent or erratic rainfall pattern during the session due to climate change also increases the plant's need for K to cope with the intermittent drought conditions that threaten crop yield (CHOUDHARY et al., 2024). The adequate composition of K in the plant tissue helps the plant withstand drought conditions by regulating the stomatal opening and maintaining the plant's integrity (HASANUZZAMAN et al., 2018). Soil K depletion is also affected by rainfall. The availability of K in the soil is generally affected by rainfall due to its mobility and poor soil-chelating properties (BELL et al., 2017). Intensive rainfall causes the dissolved K to leach beyond the reach of the crop root leading to poor K nutrition. However, the attempt to redress K deficiency in the soil could impact crop performance when not judiciously managed (CHOUDHARY et al., 2024). Rather than improving crop growth, it may retard crop development because of soil nutrient imbalance.

The influence of an adequate K supply in crop nutrition is associated with an enhancement in nutrient assimilation (YIN et al., 2023), protein synthesis, photosynthesis and hydraulic homeostasis. However, under inadequate conditions, poor K nutrition limits the growth of strong stems, and tolerance to high light intensity reduces the plant's resistance to some diseases (HASANUZZAMAN et al., 2018). Also, the plant's ability to moderate moisture loss from growing plants is affected by climate drought resistance. The unavailability of K in garden eggs results in poor fruit flavour, colour and storage quality (ADJEI et al., 2023). Therefore, to fully achieve the nutrient requirement and the quest for a healthy diet of consumers through vegetables, the fruit must be of good quality. There are many sources of fertiliser to meet the K's need for crops, such as organic and commercial sources. However, of the commercial sources, the most commonly used source is the concentrated granular form of K referred to as KCl or muriate of potash (MOP), which supplies 60-63% K_2O (MIKKELSEN & ROBERTS, 2021). This source is readily available, cost-effective, and has a granule size that allows for accurate spreading.

Adding MOP to improve the soil nutrient supply for enhanced crop performance also affects the soil ecosystem, thus influencing soil health. One of the parameters neglected in the multiplier effects of k addition to the soil is how K in the form of MOP affects soil microbial communities (HARO & BENITO, 2019). Depending on the inherent level, soil pH, organic matter content and source, K application impacts microbial communities. Using MOP as a K source could reduce nitrogen mineralisation and minimise microbial activities or interact with the soil nitrate and produce chlorine gas that reduces the population of soil microbes (PEREIRA et al., 2019). A high presence of K in the soil was reported to also affect the soil's physical condition by reducing the soil structure and limiting the pores spaces causing a reduction in the available air for respiration by the microbes (AZIZI et al., 2016; LIU et al., 2024). Also, the injudicious use of MOP may lead to P: K imbalance or Ca deficiency that affects soil microbial activities or causes environmental pollution. Consequently, there is a need to verify the impact of MOP applied for crop growth enhancement on soil microbes. Therefore, this study aimed to investigate the effects of MOP on garden egg growth and changes in microbial population.

2. MATERIAL AND METHODS

Experimental location

The study was a screenhouse experiment conducted in 2022 and 2023 at the Department of Crop and Horticultural Sciences, University of Ibadan, Nigeria. The study location coordinates were 7°27´N, 3°53´E, and 234 m above sea level.

Soil Analysis

Topsoil (from the 0–15 cm layer of the surface) used in the study was collected from the Agronomy experimental field at the University of Ibadan, Ibadan, Nigeria. A portion of the soil sample from the field (200 g) was obtained for routine laboratory analysis. The soil samples were air-dried and sieved (2.0 mm) to determine the physical and chemical properties, following standard procedures (CARTER & GREGORICH, 2007). The KCl fertiliser (MOP) was also analysed to determine the amount of available K in the fertiliser according to IFA (2009). The values of the soil properties are presented in Table 1.

Table 1. Physical and chemical properties of the soil at the experimental site

Parameters	Value	**Critical value** (Enwezor et al., 1989)	Remarks
Soil textural class (%)			
Sand	79	50 - 70	
Silt	13	20 - 40	
Clay	8	10 - 30	
Chemical properties			
pH (water) 1: 2	6,7	6.5 - 8.5	
Organic C (%)	1,98	2 - 5	Moderate
Total N (%)	3,26	1 - 3	Adequate
Avail. P (mg kg^{-1})	14	10 - 40	Moderate
K (cmol kg^{-1})	0,46	2 - 4	Low
Ca (cmol kg^{-1})	1,5	6 - 12	Low
Mg (cmol kg^{-1})	0,79	3 - 6	Low
Na (cmol kg^{-1})	0,33	0.5 - 1.5	
Cu (mg kg^{-1})	0,85	2 - 10	
Fe (mg kg^{-1})	10,9	10 - 40	
Zn (mg kg^{-1})	1,11	5 - 20	
Mn (mg kg^{-1})	97,00	5 - 30	

Treatments and Experimental Design

The treatments involved MOP at 0, 15, 30, and 45 kg K_2O ha^{-1}. The source of potassium fertiliser was KCl, containing 60% K_2O. The pot experiment was laid out in a completely randomised design with five replicates.

Soil Microbial Population Determination

The determination of soil microbial populations for bacteria and fungi was conducted before and after the study using the serial dilution method (BEN-DAVID & DAVIDSON, 2014).

Nursery planting

Seeds of the Bello variety of garden egg were sown in nursery trays filled with coco peat on February 11, 2022, and March 17, 2023, at the screenhouse of the Department of Agronomy, University of Ibadan, Ibadan, Nigeria. One seed was sown per hole in the nursery trays and later transplanted into planting bags four weeks after planting. Microfertiliser solution was applied to the seedlings about two weeks after planting. This was done to provide nutrients to the seedlings.

Pot preparation and planting procedures

Each polythene bag with 30 x 40 cm length and breath was filled with 10 kg of soil obtained from the field, and the treatments were applied one week after transplanting. The planting bags were labelled according to the applied treatments. The bags are spaced 60 cm between rows and 40 cm within rows (DEGRI, 2014). Daily watering was carried out during the first and second growing periods. Transplanting was carried out six weeks after sowing. Adequate watering was done before transplanting to facilitate the removal of the seedling. The seedlings were transplanted at a seedling per pot.

Data collection

Plant height was measured from the base of the plant to the tip with the aid of a ruler and the number of leaves was counted visually. The garden egg leaf area was calculated using Rivera et al. (2007) formula:

$$LA = 0.641(L \times W) \qquad (1)$$

Where LA = leaf area, L = the length of the leaf from tip to base, and W = the breadth of the leaf. The leaf lengths and width were measured using a ruler. The yield parameters included the number of fruits per plant and the fruit weight per plant. Plant samples were collected 45 days after transplanting and oven-dried at 85°C to a constant weight to determine dry weight.

The data were subjected to variance analysis using GenStat 10.3DE version. A Post Hoc test was performed to separate the significantly different means using the Least Significant Difference (LSD) at a 5% probability level.

3. RESULTS AND DISCUSSION

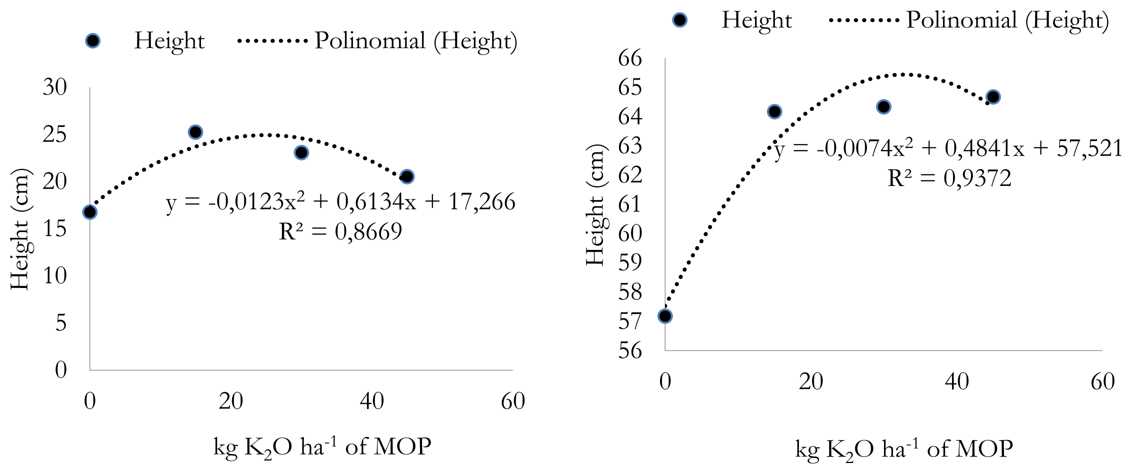
The influence of MOP application on the height of garden egg

The variation in the responses of garden eggs to MOP application was not significant for plant height during the first planting (Table 2). However, the plants treated with 30 kg K_2O ha^{-1} had the tallest plants at 2 and 4 WAT, while plants treated with 15 kg K_2O ha^{-1} had the tallest plants at 6 and 8 WAT. Applying 45 kg K_2O ha^{-1} resulted in the shortest plants at 2 WAT and the control had the lowest plant height values at 4 WAT. The plants under the control were shortest at 6 WAT. The response of garden egg to MOP application was not significant at 2, 4, and 6 WAT in the second planting. The tallest plants at 2 and 6 WAT were observed under 45 kg K_2O ha^{-1} application level and the 15 kg K_2O ha^{-1} treated plants were tallest at 4 WAT. At 8 WAP, the polynomial regression curve indicated that the optimum plant heights (25 and 65 cm) were observed at 24.93 and 32.70 kg K_2O ha^{-1} of MOP during the first and second plantings, respectively (Figure 1). While the increase in MOP application did not significantly influence garden egg height during the first planting, MOP-treated plants had significantly ($p<0.05$) taller plants than the control in the second planting. The increase in the heights of garden eggs resulting from MOP application compared to the control could be attributed to the improvement in the nutrition of the crop by K application. Furthermore, an increase in the level of K_2O application enhanced garden egg performance. The positive response of garden eggs to K application was also reported by Adjei et al. (2023). They found that the K-applied helped increase garden egg height. This result also corroborates the findings of Khaskeli et al. (2023) that increasing K application helped improve tomato height. The increase in K applied to the plant helped maintain suitable leaf inclination through turgor control, thus facilitating light interception (SARDANS & PEÑUELAS, 2021). Consequently, the photoassimilates in the fertilised plants are increased, providing the required energy for increased plant height. Potassium in rational quantity in the plant promotes cell wall elongation by stimulating ATPase, increasing height (XU et al., 2022). However, the polynomial curve predicted negative values, implying an upside-down shaped curve with the optimum point. Thus, the treatment with MOP applied at approximately 25 and 33 kg K_2O ha^{-1} had the tallest plants at 8 WAT during the first and second planting. The additional increase in K application above the optimum resulted in decrease in heights.

Table 2. Influence of muriate of potash on garden egg plant height (cm)

MOP	**First planting** (WAT)			**Second planting** (WAT)		
(kg K_2O ha^{-1})	2	4	6	2	4	6
0	7,83a	8,17a	12,58a	14,67a	27,00a	48,17a
15	6,33a	8,75a	18,75a	13,15a	34,83a	54,83a
30	9,17a	9,50a	14,83a	15,07a	30,67a	54,50a
45	7,75a	8,17a	15,33a	15,92a	30,33a	55,83a
LSD	ns	ns	ns	ns	ns	ns

WAT = weeks after transplanting; MOP = muriate of potash; ns = not significant at p<0.05.



First planting **Second height**

Figure 1. Relationship between height and rate of muriate of potash (MOP) at 8 weeks after planting during the first and second plantings

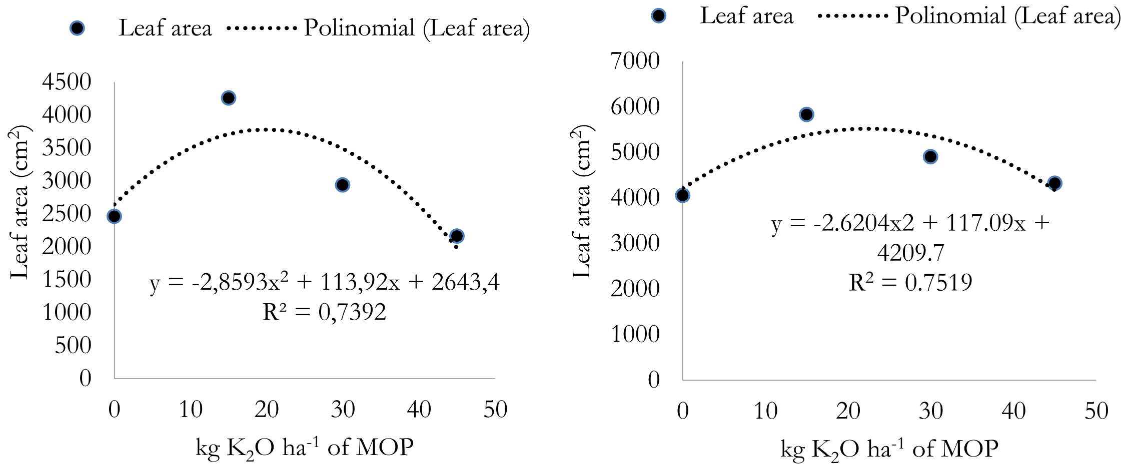
Garden egg leaf area as affected by MOP application

The responses of garden eggs to MOP application were similar for leaf area throughout the observation periods during the first planting (Table 3). However, plants treated with 30 kg K_2O ha^{-1} had the highest leaf area value at 2 WAT and plants treated with 15 kg K_2O ha^{-1} had the highest values at 4, 6 and 8 WAT. The plants under the control treatment had the lowest leaf area values at 2, 4 and 6 WAT. The 30 kg K_2O ha^{-1} treated plants had significantly higher leaf area than the control at 2 WAT during the second planting. At 4 and 6 WAT, garden egg leaf areas were similar for all treatments, however, the control and 15 kg K_2O ha^{-1} treatments had the lowest and highest leaf area values, respectively. The relationship between the rate of MOP application and leaf area at 8 weeks after planting during the first and second plantings indicated the highest leaf areas were at 29.79 and 25.02 kg K_2O ha^{-1} of MOP with the R^2 values of 0.74 and 0.75, respectively (Figure 2). The variation in leaf area at the early stage of growth could be attributed to noticeable difference in recovery from transplanting shock. This assumption is supported by Zhang et al. (2020) in that plants modify their growth to cope with stress. This finding substantiated Attia et al. (2022) on *Ocimum basilicum*. They reported that rational availability of K increases leaf expansion, suggesting an increase in photosynthesis rate and simultaneously promoting accumulation of assimilate for development. Additionally, K accelerates the synthesis of chlorophyll, improves the structure of chloroplasts, and regulates the concentration of substances in the cells of plants (LI et al., 2021). This ensures proper growth of the plant. Similarly, low K content in the cell vacuole decreases cell turgor, causing reduced cell wall extension, thus affecting leaf area (HU et al., 2020). However, the decline in the leaf area after 20 kg K_2O of MOP indicated that the increased level could have resulted in the increased transpiration rate, thus enhancing the metabolism of assimilates. This was substantiated when a higher K application resulted in a further decrease in the observed leaf area.

Table 3. Effect of muriate of potash (MOP) on garden egg leaf area.

MOP	First planting (WAT)			Second planting (WAT)		
(kg K_2O ha^{-1})	2	4	6	2	4	6
0	48,60a	170,47a	1012,27a	95,75b	355,00a	2069,74a
15	103,00a	537,95a	2381,43a	106,93ab	459,90a	2944,11a
30	116,49a	205,92a	1313,63a	132,33a	373,50a	2231,18a
45	75,21a	191,68a	1175,04a	103,40ab	366,67a	2112,46a
LSD	ns	ns	ns	31,58	ns	ns

WAT = weeks after transplanting; MOP = muriate of potash; ns = not significant at p<0.05.



First planting **Second planting**

Figure 2. Relationship between leaf area and rate of muriate of potash (MOP) at 8 weeks after planting during the first and second plantings.

Effect of muriate of potash on garden egg number of leaves

The responses of garden eggs to MOP application were not significantly different for the number of leaves at 2 WAT but ranged from 3.08 to 4.08 (Table 4). However, the number of leaves observed at 15 kg K_2O ha^{-1} was significantly higher than other treatments at 4 WAT. At 6 WAT, 15 kg K_2O ha^{-1} had 23.66, 15.73 and 43.97% higher number of leaves than 30, 45 and 0 kg K_2O ha^{-1}, respectively. During the second planting, the number of leaves observed was not significantly different among the treatments. However, the control had the highest number of leaves at 2 and 4 WAT, while plants treated with 15 kg K_2O ha^{-1} of MOP had the highest values at 6 WAT. At 8 WAP, the polynomial regression curves indicated that MOP application at 26.13 and 28.53 kg K_2O ha^{-1} was the optimum dose for the maximum number of leaves (Figure 3). The application of different levels of MOP did not significantly enhance leaf initiation during the two plantings, with the highest effect observed at 26.13 and 28.53 kg K_2O ha^{-1} with the R^2 values of 0.77 and 0.66 for the first and second plantings, respectively. The result of this study supports Lin & Yeh's (2008) report that the K application had no appreciable influence on the production of new leaves in *Guzmania lingulata* (L.) Mez. However, the moderate supply of K promotes root system development, encouraging more nutrient uptake and facilitating cell proliferation in the plant tissue. Consequently, the availability of photo-assimilation through the K-applied provides the required energy for vegetative organs to grow (CHOUDHARY et al., 2024). Depending on the location of the cell multiplication, there would be an increase in elongation that translates to a vertical rise or initiation of new leaves along the plant stem. The observed decline in the number of leaves after the optimum dose of MOP application could indicate that these levels were excessive for the plants, thus causing a reduction in this parameter. Excess K application has been reported to lead to a decrease in vegetative growth. The cause of the reduction in growth was attributed to the role played by K under excessive conditions by restricting the rooting system, antagonising the functioning of Ca, Mg and P uptake, limiting N metabolism, and reduced photosynthesis and photosynthate translocation which caused the overall reduction in vegetative growth (TRÄNKNER et al., 2018; LIU et al., 2020). Furthermore, excessive soil K leads to poor soil physical condition and increased Cl gas release that limits microbial activities, which could have aided in the mineralisation of nutrients for plant uptake (PEREIRA et al., 2019; LIU et al., 2024).

Table 4. Number of garden egg leaves as affected by muriate of potash application (MOP)

MOP	**First planting (WAT)**			**Second planting (WAT)**		
(kg K_2O ha^{-1})	**2**	**4**	**6**	**2**	**4**	**6**
0	3,08a	5,33b	11,25a	6,17a	10,00a	17,00a
15	4,08a	8,17a	20,08a	5,67a	9,00a	23,67a
30	3,75a	5,50b	15,33a	5,83a	9,83a	19,50a
45	3,67a	5,50b	16,92a	5,33a	8,67a	21,33a
LSD	ns	2,64	ns	ns	ns	ns

WAT = weeks after transplanting; MOP = muriate of potash; ns = not significant at $p<0.05$.

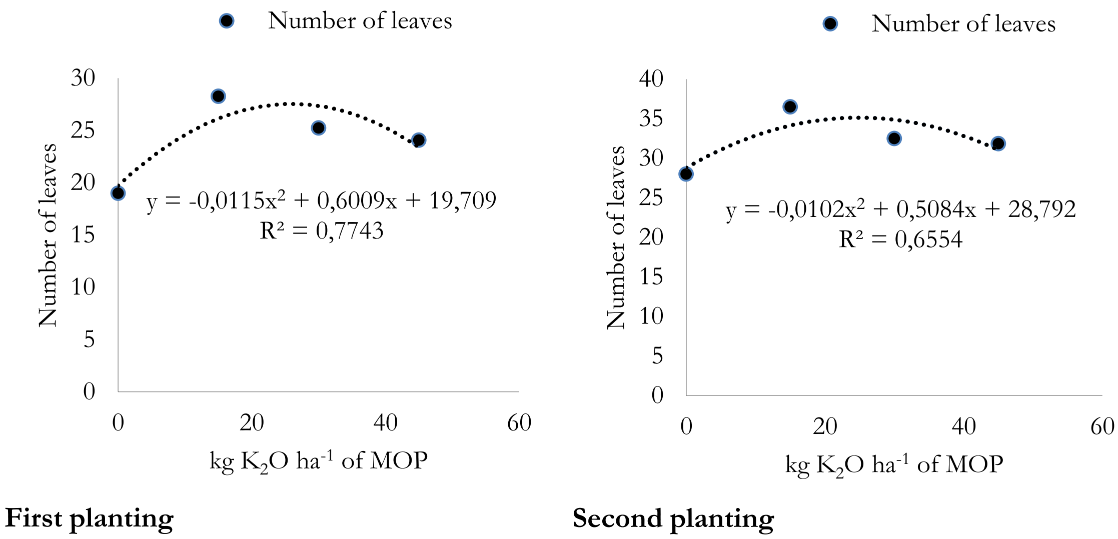
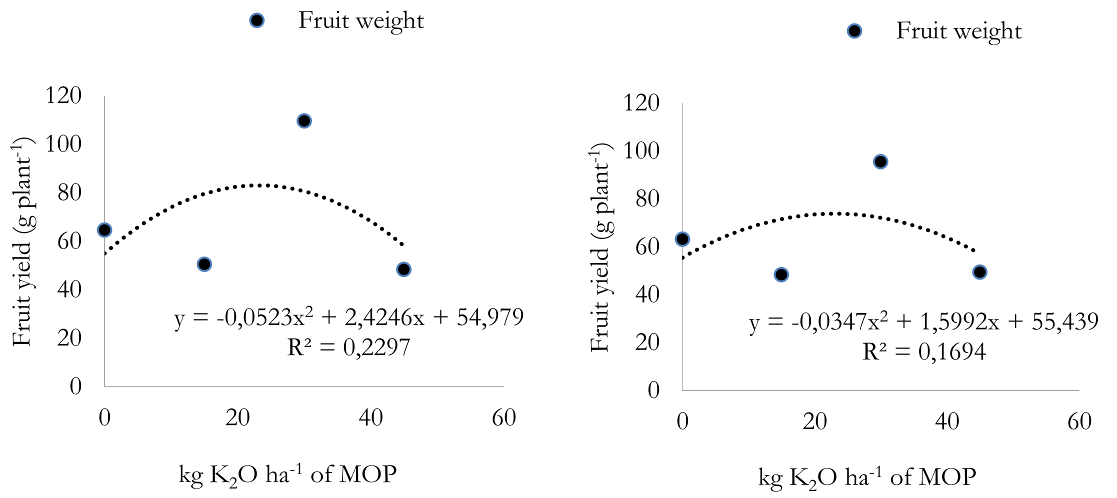


Figure 3. Relationship between leaf area and rate of muriate of potash (MOP) at 8 weeks after planting during the first and second plantings

Influence of muriate of potash application on the fruits and dry shoot weights of garden egg

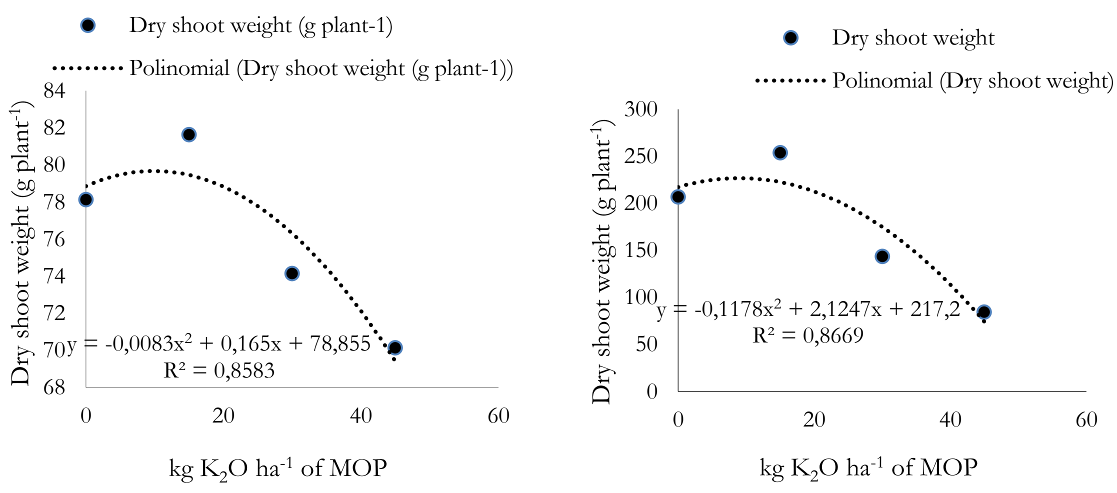
During the first and second plantings, the MOP application variations significantly influence garden fruit weights (Figure 4). Despite that the residuals were randomly scattered, the polynomial curves at a degree of 2 for the first and second planting revealed a low quadratic regression fitness of R^2 (0.22 and 0.17, respectively) for the two planting periods. The fruit weight mean values were higher than plants treated with 15 and 45 kg K_2O ha^{-1} of MOP but were similar to the control for the two plantings. However, the curves indicated the level of MOP application for optimum fruit yieds were 30.81 and 23.05 kg K_2O ha^{-1} of MOP during the first and second plantings, respectively, The higher fruit yield at these levels could be attributed to better K nutrition, which increases the photoassimilate accumulation of plants than in other treatments (LI et al., 2021). Sufficiency in K nutrition increases the absorption and utilisation of water and nutrients, encourages photoassimilates and ultimately increases crop yield (TRÄNKNER et al., 2018). The fruit yield resulted from the transportation and redistribution of assimilates produced and stored in vegetative organs (LIU et al., 2020). The fruit yield observed for MOP applications between 25 and 30 kg K_2O ha^{-1} with the highest growth parameters during the two plantings suggested a consistency in the dry matter partitioning of plants. Consequently, the 30.81 and 23.05 kg K_2O ha^{-1} treated plants had a more efficient partitioning than plants treated with lower or higher doses. Fan et al. (2023) substantiated in their study that dry matter accumulation and partitioning in plants are regulated by soil fertility, thus affecting yield. Conversely, improvement in yield at 30.81 kg K_2O over 23.05 kg K_2O suggests that there could be a variation in K utilisation efficiency during the partitioning of accumulation. At a higher K application above the optimum, garden eggs' fruit yield decreased, indicating poorer vegetative growth due to unhealthy growing conditions. Contrary to earlier reports suggesting that tropical soils are adequate in potassium (K) due to the availability of non-exchangeable forms of K for plant uptake (FIRMANO et al., 2020), this study confirmed that careful application of K is essential for achieving optimum yields of garden eggs.



First planting **Second planting**

Figure 4. Relationship between fruit weight and rate of muriate of potash (MOP) at 8 weeks after planting during the first and second plantings

The response of garden egg dry shoot biomass was significantly affected by MOP application during the first and second plantings (Figure 5). The polynomial regression curves for dry shoot biomass had a very high significant ($P<0.001$) fitness (R^2 values of 0.86 and 0.87) for the first and second plantings, respectively. The curves indicated that the optimum garden egg dry shoot weight was at 14.53 and 16.60 K_2O ha^{-1} of MOP during the first and second plantings, respectively. The negative coefficient in quadratic equation suggests the increase in the level of MOP application above the optimum results in a further reduction in dry shoot biomass during the first and second planting, The observed crop dry shoot weight indicates the plant's ability, through K acquisition, to accumulate photoassimilates in the shoot system (HU et al., 2016). Providing an enabling environment for crops through K application increases the ability of the plant to accumulate carbohydrates for growth (LI et al., 2021). The availability assimilates serves as the source of energy for dry matter production. This study indicated that for dry shoot weight, the highest response of garden egg to K fertiliser application was between 14.53 and 16.60 kg K_2O ha^{-1}, while the higher level decreased dry biomass accumulation. Consequently, successive increase in K fertiliser causes limited vegetative growth in garden eggs. This result could be attributed to the observed growth parameters, in which plants treated with optimum K nutrition had the highest leaf area and the number of leaves, which are the indicators considered as the plant's photosynthetic apparatus for photosynthate accumulation that promotes yield (TRÄNKNER et al., 2018).



First planting **Second planting**

Figure 5. Relationship between dry shoot weight and rate of muriate of potash (MOP) at 8 weeks after planting in the first and second plantings

Influence of muriate of potash application on the bacterial and fungal colonies

Garden egg planting significantly increased bacterial colonies in the soil compared to the initial colonies during the first and second plantings (Figure 6). The data points were well fitted through the polynomial regression curve with the R^2 values of 0.85 and 0.94 ($p<0.001$) during the first and second plantings, respectively. Muriate of potash application also increased bacterial colonies in the soil compared to the control, with a decline after the optimum doses at 25.29 and 26.75 kg K_2O ha^{-1} during the first and second plantings, respectively.

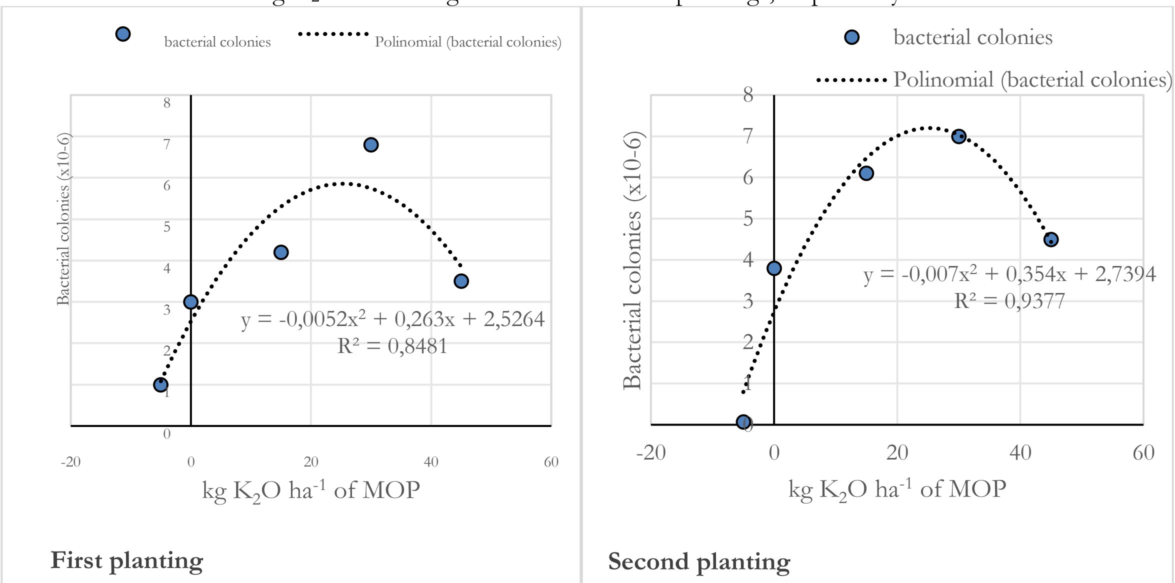


Figure 6. Relationship between rate of muriate of potash (MOP) and bacterial colonies at 8 weeks after planting in the first and second plantings

Fungal colony-forming units in the soil were significantly increased with MOP application during the first and second plantings (Figure 7). The data points during the first plantings indicated that the fungal colonies before planting were similar to the observed colonies at 0 kg K_2O ha^{-1} after the first planting. The fungal colonies before planting was considerably higher in the control after planting during the second planting. The polynomial regression curves for the first and second plantings revealed the optimum fungal colonies were at 33.85 and 23.25 kg K_2O ha^{-1} of MOP, respectively. The R^2 values (0.86 and 0.91) for both plantings were very high.

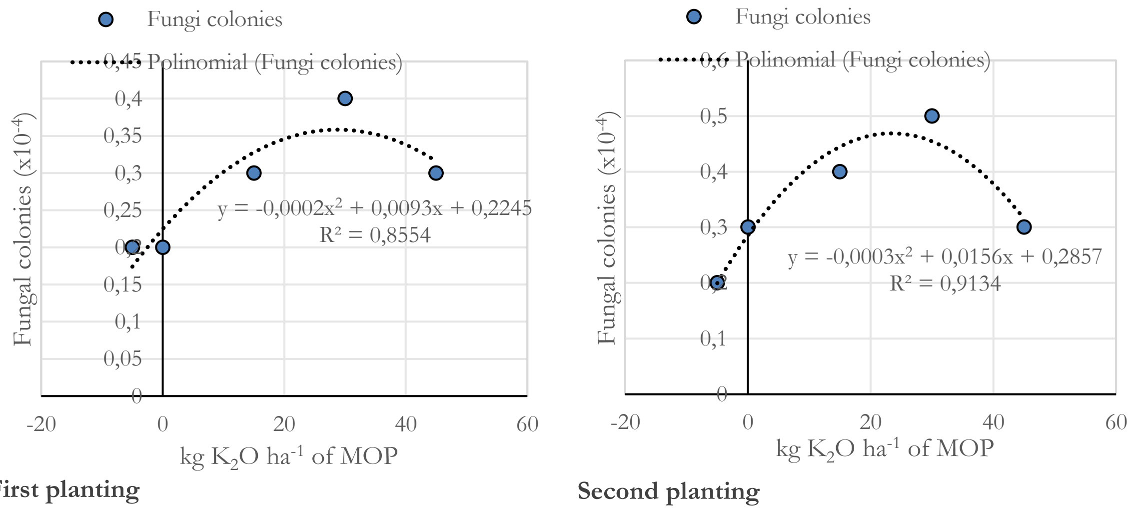


Figure 7. Relationship between rate of muriate of potash (MOP) and bacterial colonies at 8 weeks after planting in the first and second plantings

The trends observed for bacterial and fungal colonies in this study were similar. The microbial colonies observed after the garden egg harvest encouraged the bacterial and fungal communities during both plantings. This could have resulted from the provision of organic matter from the deposition of decayed roots from the garden egg

(DIJKSTRA et al., 2021; LOPEZ et al., 2023). Similarly, the plants could provide bioactive molecules into the rhizosphere (MOLEFE et al., 2023). The available organic carbon from the decayed roots and the substrates from the root must have served as the energy source for microbial proliferation. Furthermore, increasing MOP application during the two plantings favoured bacterial and fungal colonies. The role of K in crops is that of encouraging the root system of the crop to acquire more nutrients (HARO & BENITO, 2019), during which organic carbon and organic substances are simultaneously deposited into the rhizosphere (DIJKSTRA et al., 2021; MOLEFE et al., 2023). The deposited carbon provides materials for the increase in microbial activities. The substantial increase in microbial colonies at the optimum doses could have occurred during the final vegetative stage, thus aiding the availability of nutrients through the assimilate partitioning period (since the colonies were not measured over time). However, the result of the two plantings in this study suggests that excessive increases of MOP in garden eggs could lead to a decline in both bacterial and fungal colonies. Although the effect of MOP application on bacteria and fungi was not separated, Pereira et al. (2019) also reported that a high level of MOP application caused a reduction in soil microbial activities. The reduced microbial colonies under higher MOP conditions could cause a decrease in nitrogen mineralisation and increased chlorine gas production, reducing the presence of soil microbes (PEREIRA et al., 2019). The low microbial presence in the soil at a higher MOP application in this study could have been an indicator of deficiency in soil health due to high K application, consequently leading to poor garden egg performance.

4. CONCLUSION

This study established the need for applying potassium fertiliser for improved growth and yield of garden egg. Potassium application through MOP between 25 and 30 kg K_2O ha^{-1} favoured garden egg height, leaf area and the number of leaves over the observation periods compared to the other levels considered. Similarly, using 30.81 and 23.05 kg K_2O ha^{-1} of MOP optimises garden egg fruit yields and microbial colonies at harvest, except for dry shoot biomass. Conclusively, in other to minimise the possible escalation of the environmental cost of high K application, 25 kg K_2O ha^{-1} of MOP was considered rational for fostering sustainable garden egg production.

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