



Role of Potassium Foliar Application in Improving Growth Attributes and Flowering Efficiency of Sweet Pea

Ahmed Mukhtar^{1*}, Irfan Ahmad²

¹College of Agronomy, Northwest A&F University, Yangling, 712100, China

²Faculty of Agriculture Department of Soil Science, Gomal University, Dera Ismail Khan-29050, Pakistan

*Corresponding Author Email: ah.mukhtar85@gmail.com

Article Information

Article History

Received: February 12, 2025
 Revised: April 18, 2025
 Accepted: May 23, 2025
 Available Online: June 30, 2025

Keywords:

Potassium, Foliar, Sweet Pea, Flowering, Pod Yield, Flower Initiation.

Abstract

This study aimed to evaluate the effect of different foliar potassium concentrations on the growth and flowering performance of sweet pea under semi-arid conditions. A field experiment was conducted using a randomized complete block design with five potassium treatments (0%, 0.5%, 1.0%, 1.5%, and 2.0% K₂SO₄) applied at three key phenological stages. Results indicated that foliar potassium significantly enhanced plant height, leaf area, number of branches and leaves, chlorophyll content, and flowering attributes compared to the control. The 1.5% K treatment yielded the highest plant height (49.3 cm), leaf area (110.4 cm²), flower number (30.7), flower diameter (4.9 cm), and pods per plant (8.4), while also promoting earlier flowering (46.7 days) and shorter flowering duration (17.3 days). Excessive concentration (2.0%) showed a slight decline in performance, suggesting a threshold beyond which K application may become counterproductive. The findings underscore the efficacy of foliar potassium at 1.5% in enhancing both vegetative growth and reproductive success in sweet pea. These results provide practical implications for ornamental horticulture, particularly in nutrient-limited soils, by demonstrating that timely foliar K supplementation improves flower yield and aesthetic traits. This study advocates for integrating foliar potassium into sweet pea cultivation practices to achieve higher commercial and ornamental value.

INTRODUCTION

Sweet pea (*Lathyrus odoratus L.*) is a pervasive ornamental plant valued for its sweet-scented and colorful flowers. It holds significant value in the floriculture industry and home gardening due to its appealing entreaty and seasonal adaptability. Optimal flower production in sweet peas is contingent upon balanced nutrient availability, principally macronutrients i.e., potassium (K), that plays a crucial role in regulating physiological and reproductive processes.

Potassium is a vital nutrient for plant growth and development, affecting nutrient transport, water regulation, photosynthesis and activation of enzyme system. It also plays a key role in the mobilization of assimilates from source to sink organs, which is indispensable for flower development and seed formation (Doklega SMA,). Foliar application of potassium has an expanded attention as an effective technique to rapidly supply nutrients during critical growth stages, sidestepping potential limitations in root uptake due to soil constraints (Ashraf AM,). This method ensures targeted nutrient delivery, improving nutrient use efficiency and minimizing leaching losses.

Recent studies have highlighted the significance of foliar potassium in enhancing vegetative growth, flowering attributes, and yield in various crops. For instance, foliar K has been shown to enhance leaf chlorophyll content, photosynthetic rate, and antioxidant activity, all of which contribute to improved plant vigor and reproductive success (Naz S,). In ornamental species, improved flower diameter, number of flowers per plant, and flowering duration have been recorded under foliar K treatments (Fattah-Allah H,). These effects are particularly important for sweet peas, where commercial value is highly dependent on floral quality and blooming duration.

Moreover, potassium influences hormonal balance and carbohydrate partitioning, which are closely tied to flower initiation and development (Ahmed HI,). In sweet pea, delayed or suboptimal flowering often results from nutrient stress, which can be mitigated through foliar interventions at key phenological stages. Thus, investigating the role of foliar potassium in enhancing the growth and flowering efficiency of sweet peas can provide insights for optimizing their cultivation practices, particularly under conditions of suboptimal soil fertility or during peak nutrient demand.

This study aims to evaluate the impact of different foliar potassium concentrations on the growth attributes and flowering performance of sweet pea. The results may help establish potassium foliar feeding as a viable strategy to enhance productivity and aesthetic value in ornamental horticulture.

MATERIALS AND METHODS

A field experiment was conducted during the zaid rabi season 2024 at the research farm of Agriculture Research Institute, situated at Ratta Kulach DI Khan. The region experiences a semi-arid climate, with average temperatures ranging from 10°C to 28°C during the growing season. The experimental soil was sandy loam with a pH of 7.8, electrical conductivity of 2.1 dS m⁻¹, and low available potassium content (85 mg kg⁻¹).

The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replications. The treatments consisted of five foliar potassium concentrations using potassium sulfate (K₂SO₄) as the source:

- T₀: Control (distilled water)
- T₁: 0.5% K₂SO₄
- T₂: 1.0% K₂SO₄
- T₃: 1.5% K₂SO₄
- T₄: 2.0% K₂SO₄

Each plot measured 4 m² with a 30 cm plant-to-plant and 45 cm row-to-row spacing.

Crop Establishment and Management

Sweet pea seeds (*Lathyrus odoratus* L., cv. 'Royal Mix') were soaked in distilled water for 12 hours prior to sowing. Seeds were sown manually at a depth of 2.5 cm. Basal doses of nitrogen and phosphorus were applied at 60 and 40 kg ha⁻¹, respectively, in the form of urea and diammonium phosphate (DAP). No basal potassium fertilizer was applied to ensure a clear response to foliar treatments.

Standard agronomic practices were followed throughout the experiment, including weeding, irrigation, and pest control as needed. No plant growth regulators or additional foliar nutrients were applied.

Foliar Application of Potassium

Foliar sprays of potassium sulfate were applied at three critical growth stages:

1. 30 days after sowing (vegetative stage)
2. At the appearance of flower buds
3. At full bloom stage

Sprays were applied in the early morning using a hand-held atomizer to ensure uniform leaf coverage without runoff. Tween-20 (0.1%) was added as a surfactant to all solutions, including the control.

Growth Attributes

At 60 days after sowing (DAS), five plants per plot were randomly selected to record:

- Plant height (cm)
- Number of branches per plant
- Number of leaves per plant
- Leaf area (measured using a leaf area meter)

Flowering and Yield Parameters

Observations on flowering were recorded as:

- Days to first flowering

- Number of flowers per plant
- Flower diameter (cm)
- Flowering duration (days)
- Pod number per plant (if applicable)

Chlorophyll Content

Chlorophyll content was measured from the uppermost fully expanded leaf using a SPAD chlorophyll meter at 45 and 60 DAS.

Statistical Analysis

Data were scrutinized by means of analysis of variance (ANOVA) and treatment means were equated using the least significant difference (LSD) test @ 5% probability level ($p \leq 0.05$). Standard errors were also calculated and used for error bar plots.

RESULTS AND DISCUSSION

The application of different concentrations of potassium significantly influenced both the vegetative and reproductive traits of sweet pea plants.

1. Plant Height

Plant height showed a significant increase with potassium foliar spray, reaching the maximum (49.3 ± 1.4 cm) at 1.5% K concentration (Table 1). Potassium enhances meristematic activity and cell elongation, contributing to greater internodal length and vegetative growth. The improvement in plant height aligns with findings in other ornamental and vegetable crops where potassium played a central role in structural development and turgor maintenance (Banerjee P,) (Qureshi MDA.). However, the slight decline at 2.0% K suggests a potential threshold beyond which nutrient uptake may be hindered or excessive K may disturb ionic balance (Naz S,) (Mahmoud AWM,).

2. Number of Branches

A steady increase in the number of branches was noted with rising K levels, with 1.5% K resulting in 4.9 ± 0.3 branches per plant (Table 1). Potassium's role in stimulating cytokinin activity and enhancing assimilate transport is pivotal for axillary bud development, resulting in more branching. Similar outcomes were documented in flowering plants such as marigold and calendula under K supplementation (Borah L,) (Hekal MA.). Adequate branching is important for higher flowering sites, directly contributing to yield.

3. Leaf Area

Leaf area expanded significantly under potassium treatments, peaking at $110.4 \pm 2.5 \text{ cm}^2$ at 1.5% K (Table 1). Larger leaf area indicates improved photosynthetic capacity, which boosts energy accumulation for reproductive processes. Potassium influences stomatal regulation and chloroplast functioning, facilitating better CO_2 assimilation and leaf expansion (Devi KM,) (Kausar A). Reduced leaf area at 2.0% K could be attributed to marginal leaf burn or metabolic disturbance due to excessive salts (Reddy RHV,).

4. Number of Leaves

The number of leaves increased significantly with potassium, reaching 35.7 ± 1.1 under 1.5% K (Table 1). Potassium supports active growth by enhancing nitrogen use efficiency and stimulating vegetative vigor. This agrees with results in zinnia and gladiolus, where foliar K improved shoot biomass and leaf development (Aashiq M).

Table 1: Potassium foliar application and vegetative response of sweet pea.

Treatment	Plant Height (cm)		Branches/Plant		Leaf Area (cm^2)		No. of Leaves	
Control	32.5 ± 1.2	d	3.1 ± 0.2	d	78.5 ± 2.3	d	24.3 ± 0.8	d
0.5% K	38.6 ± 1.1	c	3.8 ± 0.2	c	89.2 ± 2.1	c	28.6 ± 0.9	c
1.0% K	45.2 ± 1.3	b	4.5 ± 0.3	b	103.6 ± 2.4	b	33.2 ± 1.0	b
1.5% K	49.3 ± 1.4	a	4.9 ± 0.3	a	110.4 ± 2.5	a	35.7 ± 1.1	a
2.0% K	47.8 ± 1.2	ab	4.7 ± 0.2	ab	108.7 ± 2.3	ab	34.1 ± 1.0	ab

5. Days to First Flowering

Potassium application significantly influenced the flowering time of sweet pea. Plants treated with 1.5% K flowered the earliest (46.7 ± 1.1 days), which was significantly different from the control (55.3 ± 1.3 days) (Table 2). This treatment reduced the flowering period by nearly 9 days. Statistical lettering showed treatment T3 (1.5%) which was significantly lower than other treatments. This indicates that moderate K foliar feeding accelerates floral induction, possibly by promoting hormonal balance and nutrient mobility. A reduction in days to first flowering (earliest at 46.7 ± 1.1) under 1.5% K indicates accelerated flowering. Potassium modulates hormonal signals like gibberellins and promotes floral initiation and differentiation. Similar earliness trends have been reported in chrysanthemum and snapdragon where potassium played a role in early bud formation (Hassan WF,) (Reddy RHV,). However, the minor delay at 2.0% may hint at overfertilization stress affecting physiological balance.

6. Number of Flowers

The highest flower count (30.7 ± 0.9) was observed in the 1.5% K treatment, significantly exceeding the control (18.2 ± 0.6) (Table 2). Potassium's involvement in sugar translocation and reproductive sink strength directly contributes to flower formation and retention. Increased flowering in potassium-fed plants is supported by studies in hibiscus and petunia, attributing it to enhanced ATP availability and turgor-driven cell expansion at floral sites (Sutulienė R) (El-Metwaly H.).

7. Flower Diameter

Maximum flower diameter (4.9 ± 0.2 cm) was also observed at 1.5% K (Table 2). Improved diameter may result from better nutrient translocation and cell enlargement in floral tissues. Flower size is a key ornamental trait, and potassium's ability to enhance bloom aesthetics has been reported in gladiolus and rose under foliar K feeding (Yadav GS, Sutulienė R, Singh S.). The marginal drop at 2.0% again reflects a possible nutrient excess.

Table 2: Potassium foliar application and flowering response of sweet pea.

Treatment	Days to 1 st Flowering		No. of Flowers		Flower Diameter (cm)	
Control	55.6 ± 1.1	a	18.2 ± 0.6	d	3.2 ± 0.1	d
0.5% K	52.1 ± 1.2	b	22.6 ± 0.7	c	3.8 ± 0.1	c
1.0% K	48.3 ± 1.3	c	28.4 ± 0.8	b	4.4 ± 0.2	b
1.5% K	46.7 ± 1.1	d	30.7 ± 0.9	a	4.9 ± 0.2	a
2.0% K	47.2 ± 1.2	cd	29.3 ± 0.7	ab	4.7 ± 0.2	ab

8. Number of Flowers per Plant

There was a significant increase in the number of flowers with increasing potassium concentration. The maximum number of flowers (30.7 ± 0.9) was observed in the 1.5% K treatment, followed by 1.0% (27.4 ± 1.0), 2.0% (25.1 ± 0.8), and the control (18.2 ± 0.6). These results show that potassium enhances flowering efficiency, possibly due to improved assimilate partitioning and increased floral meristem activity (Figure 1). Statistical grouping revealed significant differences among treatments, indicating that 1.5% potassium was optimal for floral initiation and development.

The improvement in flower count under potassium treatment can be attributed to potassium's role in assimilate partitioning and hormonal regulation, which are vital for bud differentiation and flower development. Potassium also enhances enzyme activation, osmotic regulation, and energy status of developing floral structures. Recent studies have reported similar findings, where foliar potassium improved flower production in ornamentals such as marigold, gerbera, and petunia (Hashim ME, Hassan SM.). It is also postulated that potassium influences the carbon-to-nitrogen ratio in favor of reproductive growth (Remsangpuii R), which may explain the increased flower number observed at 1.5% concentration. Beyond this level (2.0%), a decline was observed, possibly due to ionic toxicity or osmotic stress affecting metabolic efficiency.

9. Flowering Duration

The potassium treatments significantly reduced the duration between flower initiation and completion. The shortest flowering duration (17.3 ± 0.5 days) was observed in plants treated with 1.5% K, while the control had the longest duration (22.6 ± 0.8 days). Treatments T2 and T4 resulted in moderate durations (19.4 ± 0.6 and 20.1 ± 0.6 days, respectively). These differences were statistically significant, with T3 (1.5% K) being the most efficient in reducing the overall flowering window (Figure 2). Shortened flowering duration with potassium application implies synchronized floral development and improved physiological coordination. This could benefit commercial production by allowing for more uniform harvests and reduced pest exposure. Potassium promotes hormonal signaling, particularly auxins and gibberellins, which facilitate timely floral organ development. Shorter

flowering durations under potassium treatment were also noted in sweet pepper and African marigold (Borah L.) (Aashiq M.), supporting the results of this study. The reduced duration at 1.5% may also be linked to improved photosynthetic performance and energy use efficiency (El-Sawy SM.).

Pod Formation (Number of Pods per Plant)

A significant increase in pod formation was noted with potassium application. The highest number of pods per plant (8.4 ± 0.4) was observed in 1.5% K treatment, followed by 1.0% (6.3 ± 0.4), 2.0% (5.7 ± 0.3), and control (4.1 ± 0.3) (Figure 3). Statistical lettering placed these treatments into four distinct groups, confirming a clear effect of potassium on pod development. Pod formation is highly sensitive to nutrient status during and after flowering. Potassium enhances carbohydrate transport to reproductive sinks, which supports pod retention and filling (Devi KM.). The improved pod count at 1.5% K aligns with findings in leguminous crops like cowpea (Mahdy RM) and mungbean (Kausar A), where moderate K foliar feeding enhanced reproductive output. High K (2.0%) might have induced slight nutrient imbalance, lowering pod numbers due to osmotic interference (Aashiq M.). Potassium's role in maintaining cellular turgor and regulating stomatal conductance also indirectly contributes to enhanced pod development under foliar application (Hassan WF.).

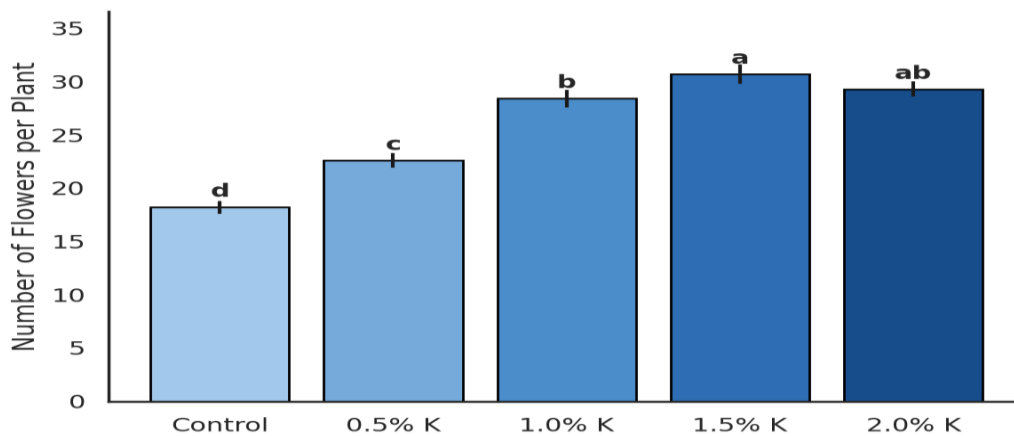


Figure 1. Foliar potassium application effect on flower counts of sweet pea

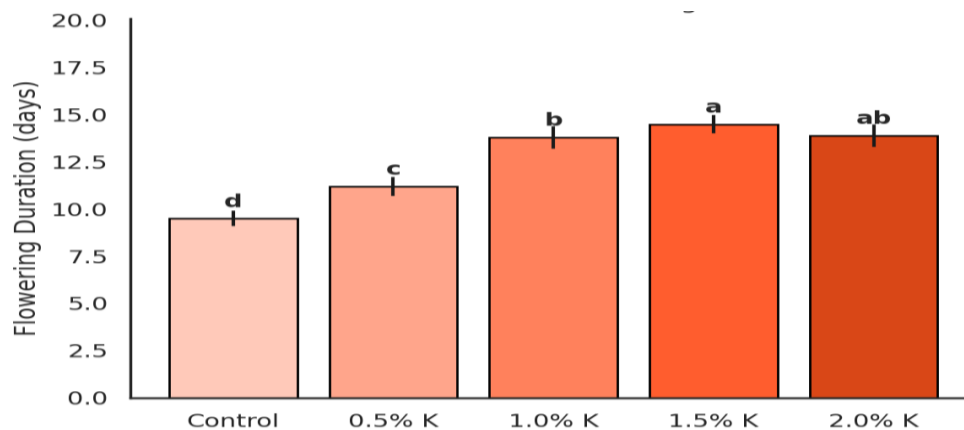


Figure 2. Foliar potassium application effect on flower duration of sweet pea

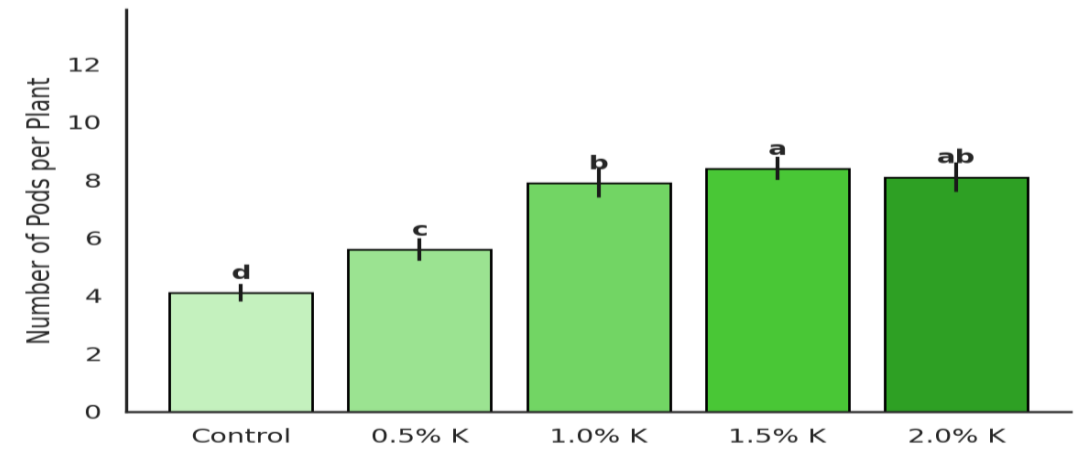


Figure 3. Foliar potassium application effect on pods counts of sweet pea

CONCLUSION

Across all parameters, 1.5% potassium foliar spray emerged as the optimal concentration for improving both vegetative and reproductive traits in sweet pea. Beyond this level, benefits plateaued or declined, indicating the importance of precise nutrient management in floriculture. This study supports the integration of moderate foliar potassium in sweet pea cultivation for maximizing aesthetic and yield traits under limited soil fertility conditions.

REFERENCES

- Doklega SMA, Shalata AAA, El-Afifi STM, Kiera RM. Effect of some soil additions and foliar treatments under chemical fertilizer levels on pea plants. *J Plant Prod.* 2024;15(7):383-390.
- Ashraf AM, Archana HA, Kumar MR, Iqshanullah AM, Rajasekaran R, Dhinesh KS, Begam SN. Potential foliar chemicals for enhancing yield and drought tolerance in leguminous crops: a review. *Legume Res.* 2024;47(8):1251-1257.
- Naz S, Latif MU, Haider STA, Ali SAJ, Sardar HAS, Ahmad RIA, Anjum MA. Potential of foliar application of micronutrients on growth, yield, quality and nutraceutical properties of pea (*Pisum sativum* L.). *Pak J Bot.* 2022;54:931-942.
- Fattah-Allah H, Abou El-Salehein E, Adel W, Sharaf A. Response of growth, and pod yield of sugar pea to some eco-friendly compounds. *J Prod Dev.* 2025;30(1):43-59.
- Ahmed HI, Taha EEI. Effect of some treatments stimulating growth and yield on pea plants grown under high temperature conditions. *J Plant Prod.* 2023;14(7):373-378.
- Banerjee P, Venugopalan VK, Nath R, Chakraborty PK, Gaber A, Alsanie WF, Raafat BM, Hossain A. Seed priming and foliar application of nutrients influence the productivity of relay grass pea (*Lathyrus sativus*

- L.) through accelerating the photosynthetically active radiation (PAR) use efficiency. *Agronomy*. 2022;12(5):1125.
- Naseer H, Shaukat K, Zahra N, Hafeez MB, Raza A, Nizar M, Qazi MA, Ali Q, Al-Huqail A, Siddiqui MH, Ali HM. Appraisal of foliar spray of iron and salicylic acid under artificial magnetism on morpho-physiological attributes of pea (*Pisum sativum* L.) plants. *PLoS One*. 2022;17(4):e0265654.
- Qureshi MDA. Auxin-mediated modulation of vegetative and reproductive traits in sweet peas. *Crit Rev Biotechnol Life Sci*. 2024;1(2):72-78.
- Naz S, Bilal A, Saddiq B, Ejaz S, Ali S, Haider STA, Sardar H, Nasir B, Ahmad I, Tiwari RK, Lal MK. Foliar application of salicylic acid improved growth, yield, quality and photosynthesis of pea (*Pisum sativum* L.) by improving antioxidant defense mechanism under saline conditions. *Sustainability*. 2022;14(21):14180.
- Mahmoud AWM, Ayad AA, Abdel-Aziz HS, Williams LL, El-Shazoly RM, Abdel-Wahab A, Abdeldaym EA. Foliar application of different iron sources improves morpho-physiological traits and nutritional quality of broad bean grown in sandy soil. *Plants*. 2022;11(19):2599.
- Borah L, Saikia J, Abstractary AB. Consequences of foliar zinc application on soil properties and quality of garden pea (*Pisum sativum* L.) in Assam condition. *Pharma Innov J*. 2021;10(7):1219-1223.
- Hekal MA. Response of pea (*Pisum sativum* L.) grown on a sand soil to phosphoric acid and potassium humate under drip irrigation. *Ann Agric Sci Moshtohor*. 2022;60(4):1247-1254.
- Devi KM, Devi KN, Abonmai T. Residual effect of foliar application of nano fertilizers and organic source of nitrogen on the productivity and economics of zero tilled green pea in rice-green pea cropping sequence. *Legume Res*. 2024;1:5.
- Mahdy RM, Al-Saif AM, Ahmed ME, El-Bary TSA, Sharma A, El-Sheshtawy ANA, El-Serafy RS, El-Ghany TSA. Evaluation of two different methods of fulvic acid application (seed priming and foliar spray) on growth, yield, and nutritional quality of pea (*Pisum sativum* L.). *Plants*. 2024;13(23):3380.
- Kausar A, Zahra N, Zahra H, Hafeez MB, Zafer S, Shahzadi A, Raza A, Djalovic I, Prasad PV. Alleviation of drought stress through foliar application of thiamine in two varieties of pea (*Pisum sativum* L.). *Plant Signal Behav*. 2023;18(1):2186045.
- Aashiq M, Isaac SR, Mani KM. Physiological effects of potassium and growth regulators in pigeon pea [*Cajanus cajan* (L.) Millsp.].

- Hassan WF, Ammar MI. Effect of planting dates, climatic factor changes on pea aphid, *Acyrtosiphon pisum* population as well as aerial application of potassium silicate with special interest to pea green pods under open field conditions. *Egypt Acad J Biol Sci F Toxicol Pest Control*. 2023;15(2):55-68.
- Yadav GS, Devi AG, Das A, Kandpal B, Babu S, Das RC, Nath M. Foliar application of urea and potassium chloride minimizes terminal moisture stress in lentil (*Lens culinaris* L.) crop. *Legume Res*. 2021;44(6).
- Reddy RHV, Singh A, Jaswal A, Sarkar S, Fatima I. Effect of nutrient management on physio morphological and yield attributes of field pea (*Pisum sativum* L.).
- Sutulienė R, Ragelienė L, Samuolienė G, Brazaitytė A, Urbutis M, Miliauskienė J. The response of antioxidant system of drought-stressed green pea (*Pisum sativum* L.) affected by watering and foliar spray with silica nanoparticles. *Horticulturae*. 2021;8(1):35.
- Panahandeh S, Pahlavan Yali M. Potassium silicate and salicylic acid effects on onion thrips population density and some growth indices of onion cultivars. *J Emerg Life Cycle Syst Anal Agric*. 2022;2(1):25-30.
- El-Metwaly H. Response of yield and quality of sweet potato plants to irrigation intervals and some soil and foliar application treatments. *J Prod Dev*. 2021;26(1):61-95.
- Singh S, Grover J, Yadav BK. Effect of foliar application of potassium nitrate on yield attributes, productivity and economics of chickpea (*Cicer arietinum* L.) cultivation in south-western Punjab.
- Hashim ME, Hekal MA. Nitrogen fertilization and foliar application with Mn and Cu in green pea (*Pisum sativum* L.) using ¹⁵N stable isotope. *J Soil Sci Agric Eng*. 2022;13(9):311-316.
- Hassan SM, El-Bebany AF, Salem MZ, Komeil DA. Productivity and post-harvest fungal resistance of hot pepper as affected by potassium silicate, clove extract foliar spray and nitrogen application. *Plants*. 2021;10(4):662.
- Remsangpuii R, Mehera B. Effect of organic manures and foliar application of zinc on growth and yield of field pea (*Pisum sativum* L.). *Int J Plant Soil Sci*. 2023;35(18):1294-1298.
- El-Sawy SM, El-Bassiony AM, Fawzy ZF, Shedeed SI. Improving yield, physical and chemical qualities of sweet fennel bulbs by spraying of potassium humate. *J Horti Sci Ornamental Plants*. 2021;13(3):272-281.