Research Article

Performance Evaluation of Different Varieties of *Mirabilis jalapa* L. Under Agro-Climatic Conditions at Ghazi Umara Khan Degree College, Samarbagh (Dir Lower)

Shakir Ullah[1*], Lubna Shakir[2], Mohammad Sohail[3], Iqbal Hussain[3], Falak Naz[3], Azmat Noreen[3], Ghani Subhan[4] and Naveen Dilawar[5]

[1]State Key Laboratory of Systematic and Evolutionary Botany (LSEB), Institute of Botany, University of Chinese Academy of Sciences, Beijing, China, 100000; [2]Govt Post Graduate College Timergara Dir Lower, Khyber Pakhtunkhwa, Pakistan; [3]Department of Botany, Garden Campus, Abdul Wali Khan University Mardan, Mardan 23200, Khyber Pakhtunkhwa, Pakistan; [4]College of Life Sciences, University of Chinese Academy of Sciences, Beijing, China 1000498; [5]Department of Botany, Women University Mardan, Mardan 23200, Khyber Pakhtunkhwa, Pakistan.

Abstract | This study aimed to identify the most suitable *Mirabilis jalapa* L. varieties for improving plant growth, flower yield, and quality under the agroclimatic conditions of Ghazi Umara Khan Degree College, Samarbagh, Dir Lower. The experiment was conducted from December to April 2020–2021 at the Research Field, Department of Botany, Ghazi Umara Khan Degree College. Using a Randomized Block Design, 15 varieties were tested with three replications. The results revealed significant variation among the 15 varieties across all observed parameters. Notably, the Non-pinch Non-stick variety exhibited the best performance in terms of height (34.77 cm), plant spread (22.90 cm^2), average flower weight (11.4 gm), flower yield per plant (134.15 gm), and shelf life (12 days). The Vijay variety showed early flower bud initiation, completing this phase in just 38 days, followed by Non-pinch Non-stick (42.47 days). However, Vijay required fewer days to flower (54 days), whereas Non-pinch Non-stick took longer (59.7 days). Additionally, Pink Princess demonstrated strong performance in multiple parameters, including the number of primary branches (13.7), number of leaves (84.44), number of flower buds (44.00), and number of flowers per plant (28.00), performing similarly to C_{26} and Scarleteer. Based on these findings, Non-Pinch Non-stick and Pink Princess are recommended for cultivation at Ghazi Umara Khan Degree College, Samarbagh, Dir Lower, due to their outstanding growth and flowering traits. It is recommended that these varieties be prioritized by local growers to maximize flower yield and quality.

Received | August 30, 2025; **Accepted** | October 10, 2025; **Published** | November 18, 2025
***Correspondence** | Shakir Ullah, State Key Laboratory of Systematic and Evolutionary Botany (LSEB), Institute of Botany, University of Chinese Academy of Sciences, Beijing, China, 100000; **Email:** shakirawkum321@gmail.com
Citation | Ullah, S., L. Shakir, M. Sohail, I. Hussain, F. Naz, A. Noreen, G. Subhan and N. Dilawar. 2025. Performance evaluation of different varieties of *Mirabilis jalapa* L. under agro-climatic conditions at Ghazi Umara Khan Degree College, Samarbagh (Dir Lower). *Journal of Plant Health, Ecology and Evolution,* 01(1): 28-38.
DOI | https://dx.doi.org/10.17582/journal.jphee/2025/01.1.28.38
Keywords | *Mirabilis jalapa* L. Non-pinch Nonstick, Pink Princess, Performance of varieties

Introduction

Mirabilis jalapa L. is a well-known ornamental horticultural plant and a commercially important flower crop (Manan *et al*., 2025). *Mirabilis jalapa* L. of the Nyctaginaceae family is a highly attractive and charming flowering plant with over 2000 varieties in the world (Joshi *et al*., 2010). The word chrysanthemum is derived from the Greek *Mirabilis*, which in Latin means wonderful, and *Jalapa* (or Xalapa) is the state capital of Veracruz in México (Irshad *et al*., 2025). *Mirabilis jalapa* is grown in pots or as cut flowers, and its success is primarily due to the wide variety of cultivars available (Jamal-Uddin *et al*., 2015). *Mirabilis jalapa is* believed to be native to the northern hemisphere, chiefly Europe and Asia, and is believed to have originated from China. (Bose *et al*., 2002; Ullah *et al*., 2025a). It is also known as four-o'clock, also called marvel-of-Peru, or beauty-of-the-night *(Mirabilis jalapa*) ornamental perennial plant of the family Nyctaginaceae, native to tropical America (Ullah *et al*., 2025b). Four-o'clock is a quick-growing species up to one meter (three feet) tall, with oval leaves on short leafstalks (Ullah *et al*., 2025c). The Autumn Queen, or the Queen of the East (Koley and Sarkar, 2013).

It is commercially grown in various parts of the world (Asif *et al*., 2025). The Netherlands, Italy, Colombia, Spain, Germany, and the United States are the most important countries where it is primarily grown in greenhouses (Ullah *et al*., 2024b). Japan is the world's leading producer of *Mirabilis jalapa* (Khan *et al*., 2024). It is the most important commercial flower crop grown in the Netherlands and Germany as a spray or cut flower, and as a potted plant in America (Ullah *et al*., 2024a). *Mirabilis jalapa* is a symbol of 'Royalty' in Japan, and it is also the national flower of Japan. (A glimpse of floriculture and landscaping) (Ullah *et al*., 2023a). The year 1995-1996 was celebrated as the "International Year of *Mirabilis jalapa*" (Shakir *et al*., 2023a). In the global flower market, chrysanthemum is the second largest cut flower after roses, and holds the fifth rank as a pot plant (Bhattacharjee and De, 2003; Shakir *et al*., 2023b).

Mirabilis jalapa is a photosensitive crop, requiring long days for vegetative growth and short days for flowering (Ullah *et al*., 2018h). *Mirabilis jalapa* is a short-day plant that fails to form flower buds if the day length exceeds 14.5 hours and fails to develop buds if the day length exceeds 13.5 hours; except for certain early flowering cultivars, the plant requires longer days for proper vegetative growth (Ullah *et al*., 2018a). *Mirabilis jalapa* is divided into two types: large-flowered (standard) and small-flowered (spray type) (Ullah *et al*., 2019c). Large-flowered *Mirabilis jalapa* with long, sturdy stems and excellent keeping quality, making them ideal for flower arrangements, cut flower production, and as a potted flowering plant for exhibition and decoration (Ullah *et al*., 2018a). Extra-large bloomed cultivars are grown for exhibition value, bouquets, vases, and so on, whereas small-flowered cultivars are grown primarily for loose flowers (Ullah *et al*., 2018b).

The variations among *Mirabilis jalapa* varieties are large in response to the environment, particularly temperature, and the interaction between temperature and cultivar occurs for every developmental trait. (Srilatha *et al*., 2015). Therefore, varietal evaluation became necessary to identify the best variety for the specific region (Khan *et al*., 2018). The performance of any crop or variety is heavily influenced by the interaction of genotype and environment. As a result, varieties that thrive in one region may not thrive in other regions with varying climatic conditions. As a result, new genotypes must be evaluated for quality traits under varying climatic conditions. The objectives of the current research were to evaluate the growth performance of different *Mirabilis jalapa* varieties under the agro-climatic conditions of Ghazi Umara Khan Degree College, Samarbagh (Dir Lower). To assess the flowering characteristics and yield of various *Mirabilis jalapa*. varieties, including parameters such as flower weight, number of flowers, and flowering duration. To identify the most suitable varieties of *Mirabilis jalapa*. for cultivation in the region based on overall growth, flowering performance, and quality traits.

Materials and Methods

Experimental site

The study on the performance of different *Mirabilis jalapa* L. varieties under agro-climatic conditions was carried out at Ghazi Umara Khan Degree College, Samarbagh, Dir Lower, to identify the best-performing varieties for this region. The experimental site is located at a longitude of 81.84º East and latitude of 25.41º North, with an altitude of 98 meters above mean sea level (Ullah *et al*., 2018g).

Climate and weather

The study site lies within agro-climatic zone V, also known as the "middle Gangetic plains" (Khan *et al*., 2018a; Ullah *et al*., 2018g). The area has a typical subtropical climate with extremes of summer and winter. Maximum temperatures reach 46–48°C during summer and rarely drop to 4–5°C in winter. The average annual rainfall is approximately 1030 mm, mostly concentrated between July and September, with occasional showers in winter (Ullah *et al*., 2018c).

Plant material and experimental design

Fifteen *Mirabilis jalapa* varieties were tested: Non-pinch Nonstick, Loyality, C_{52}, Dark Eyes, Autumn, C_{26}, Brisa, Scarleteer, Pink Princess, Yellow Lilliput, Peet, Vijay, Swetha Singar, White Bonsai, and Wall Street. The experiment was laid out in a Randomized Block Design (RBD) with 15 treatments, each replicated three times (Ullah *et al*., 2021). Rooted terminal cuttings at the 4^{th} leaf stage were transplanted at a spacing of 35 × 35 cm.

Data collection

Vegetative parameters measured included plant height, plant spread, number of branches, and number of leaves (Ullah *et al*., 2019b).

Statistical analysis

Data were subjected to analysis of variance (ANOVA). Differences among treatment means were compared using the least significant difference (LSD) test at a 5% probability level. Statistical analysis was performed using R software version 3.4.

Results and Discussion

Growth parameter

Plant height (cm): Growth parameters measured in terms of Plant height (cm), Number of branches per plant, Plant spread (cm^2), and Number of leaves per plant at 32, 62, and 92 days after transplanting in Figure 1. The plant height of *Mirabilis jalapa* showed statistically significant variation among 15 varieties at 32, 62, and 92 days after transplanting in Figure 1. The range of plant height was from 35.77 to 13.44 cm. The tallest plant was found in V_1 Non pinch Nonstick (35.77 cm), followed by V_8 Scarleteer (28.67 cm), whereas the lowest plant height was recorded in V_{10} Yellow Lilliput (13.44 cm). The difference in plant height may be due to the varietal character and vigor of the genotypes under study. Similar results were recorded in *Mirabilis jalapa* by Singh *et al*. (2017).

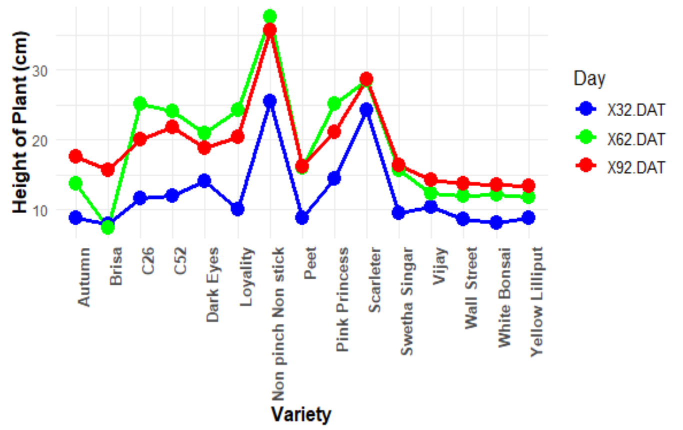

Figure 1: *Performance of different varieties of Mirabilis jalapa for plant height (cm).*

Number of branches per plant

The number of branches per plant was high in Pink Princess (13.77), followed by V_{11} Peet (10.55), whereas the lowest number of branches was found in V_2 Loyality (5), as shown in Figure 2. Variation in growth parameters among the cultivars of *Mirabilis jalapa* might be due to the genetic makeup of the cultivars having different capacities for storing reserve food materials, resulting in plant vigour. Similar results were reported by Laxmi *et al*. (2008), who found that genetic differences between varieties lead to varied growth responses, influencing traits like branching, height, and yield. Furthermore, environmental factors such as soil type, water availability, and nutrient levels can also contribute to the observed differences in growth patterns. The genetic variation observed among cultivars in this study highlights the importance of selecting appropriate varieties that match the environmental conditions to optimize growth and yield.

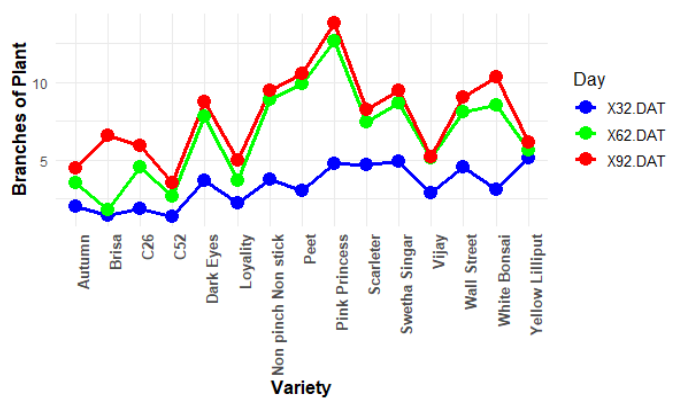

Figure 2: *Performance of different varieties of Mirabilis jalapa for the number of branches per.*

Plant spread

The range of plant spread was from 25.67 cm^2 to 13.41 cm^2. The highest plant spread was found in Pink Princess (25.67 cm^2), followed by V_8 Scarleteer (23.83cm^2), whereas the lowest was found in V_{10} Yellow Lilliput (13.41 cm^2) (Ullah *et al.*, 2018e). Plant spread differed significantly among all the cultivars, which might be due to the genetic makeup of the varieties and the development of more secondary branches in the cultivars, thereby increasing the plant spread. Similar results observed significant variation in plant spread among different cultivars of *Mirabilis Jalapa,* linked to genetic factors influencing branch development (Ullah *et al.*, 2018d). These differences in plant spread are crucial for assessing the potential of each cultivar in ornamental and agricultural applications. As shown in Figure 3, the diversity in plant spread across cultivars underscores the importance of selecting varieties based on the desired growth characteristics.

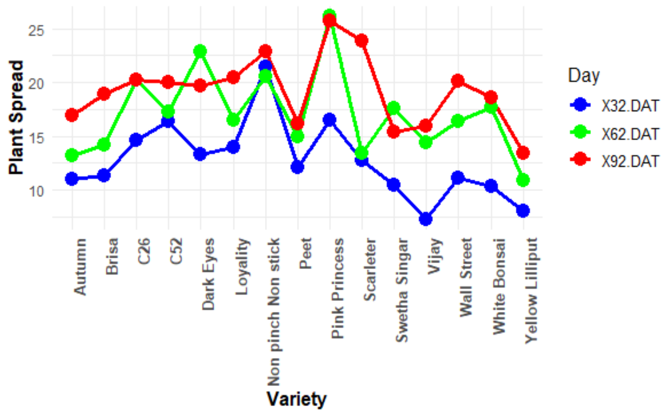

Figure 3: *Performance of different varieties of Mirabilis jalapa plants spread.*

Number of leaves per plant

The number of leaves per plant was high in Pink Princess (83.44), followed by V_4 Dark Eyes (34.11), and the lowest number of leaves was found in the variety V_{10} Yellow Lilliput (27.11). The variation in the number of leaves per plant among cultivars could be attributed to the rate of vegetative growth, which is influenced by both genetic makeup and agro-climatic conditions (Saifullah *et al.*, 2025). The genetic makeup of each cultivar governs its ability to produce leaves, while external factors such as temperature, soil quality, water availability, and light intensity can further modulate this growth. Ona *et al.* (2015) reported similar varietal evaluation results for the number of leaves in chrysanthemum, where the number of leaves was found to vary significantly among cultivars, influenced by both genetic and environmental factors. The findings in this study suggest that the selection of *Mirabilis jalapa* L. cultivars with higher leaf production may be ideal for maximizing ornamental appeal and increasing photosynthetic efficiency (Ullah *et al.*, 2019a). As shown in Figure 4, the variability in the number of leaves highlights the importance of cultivar selection based on growth characteristics. This continuation expands on the genetic and environmental factors that contribute to the variation in the number of leaves per plant, providing a clear connection to the findings by Ona *et al.* (2015) in chrysanthemum. It also ties the discussion to the ornamental and photosynthetic benefits of selecting high-leaf-producing cultivars (Khan *et al.*, 2018b).

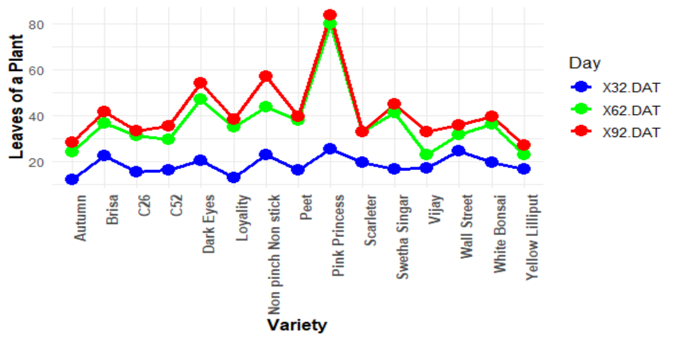

Figure 4: *Performance of different varieties of Mirabilis jalapa leaves of the plant.*

Flowering parameters

Days taken to the first flower bud appearance: Significant variation was found (visual observation) among 15 *Mirabilis jalapa* cultivars for the number of days to the emergence of the flower bud (from days after transplantation of *Mirabilis Jalapa*). Late flower bud initiation was found in V_6 C_{26} (64.6 days), while earlier bud emergence was found in V_{12} Vijay (38 days), as shown in Figure 5. This finding indicates that V_{12} Vijay (38 days) was an early flower bud cultivar, followed by Scarleteer V_8 (40.4 days). The number of days required for the first bud emergence differed significantly among all the cultivars under study. The cultivar being an early bloomer or late bloomer seems to be an inherent varietal characteristic and is influenced by the genetic nature of the plant. Mikato *et al.* (2017) reported similar results in Mirabilis Jalapa, where significant variation in flowering time was observed across different cultivars, and the genetic factors played a crucial role in determining whether a cultivar was an early or late bloomer. These findings suggest that the selection of cultivars based on flowering time could be crucial for optimizing growth cycles and ornamental use, especially when aligning with specific seasonal demands.

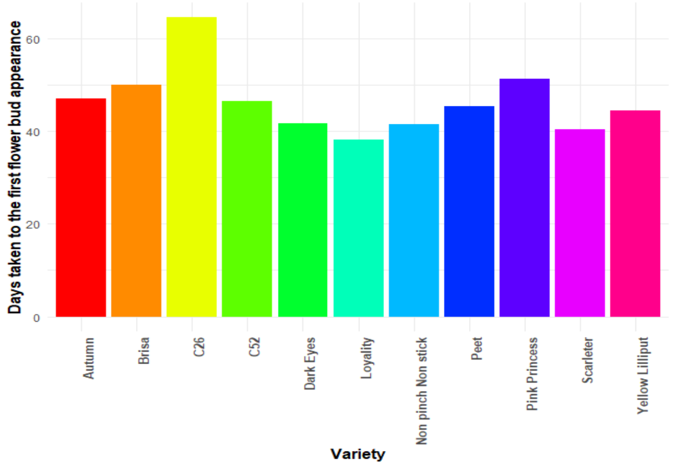

Figure 5: *Performance of different varieties of Mirabilis jalapa, days taken to the first flower bud appearance.*

Number of flowers per bud

Significant differences were observed for the cumulative number of flower buds per plant in *Mirabilis jalapa* cultivars at 30, 60, and 90 DAT, as shown in Figure 6. The maximum cumulative number of flower buds was found in V_9 Pink Princess (44.3 buds), while the minimum was found in V_7 Brisa (8.33 buds), as depicted in Figure 6. This variation in the number of flower buds per plant can be attributed to both genetic factors and environmental conditions that influence bud formation. Pink Princess, with its higher flower bud count, likely exhibits a superior genetic predisposition for bud initiation and retention, while Brisa may have a lower genetic capacity for bud production, or other factors such as nutrient availability, temperature, or water stress may have limited its potential. The findings underscore the importance of genetic traits in determining the flower bud production capacity in *Mirabilis jalapa* and similar species. This result is consistent with previous studies, which have shown that genetic differences among cultivars can significantly impact flower bud formation, leading to diverse outcomes in terms of yield potential and flowering behavior.

Number of days taken to 1st flowering

Significant variation was found among the cultivars of *Mirabilis Jalapa*, with the maximum time required for flower initiation being 55.55 days and the minimum being 94.2 days, as shown in Figure 7. This finding indicates that V_{12} Vijay (55.5 days) was an early-flowering cultivar, followed by V_5 Autumn (56.44 days). In contrast, late flowering was observed in V_3 C26 (94 days) and V_7 Brisa (93 days). The variation in flowering time can be attributed to the genetic diversity among the cultivars, with some varieties being genetically predisposed to flower earlier, while others require more time for bud initiation. The results suggest that V_{12} Vijay and V_5 Autumn are more suitable for growers seeking earlier blooms, whereas V_3 C26 and V_7 Brisa may be better suited for environments where longer flowering times are desired. Such variation in flowering time is important for selecting the right cultivars for specific ornamental or agricultural needs. These findings are in line with similar studies on Mirabilis Jalapa, where the flowering time varied significantly between cultivars, as highlighted in the research by Laxmi *et al.* (2008).

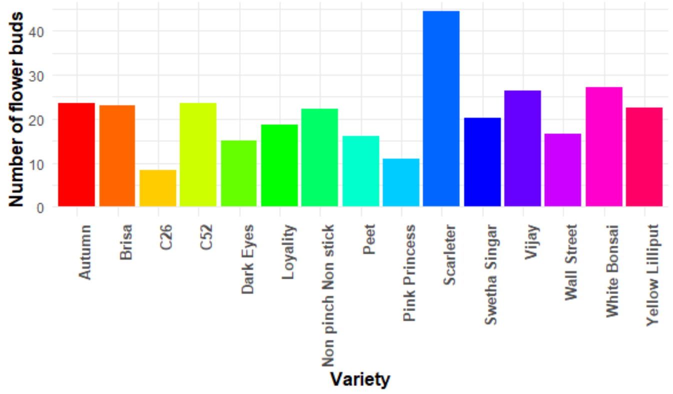

Figure 6: *Performance of different varieties of Mirabilis jalapa, number of flower buds.*

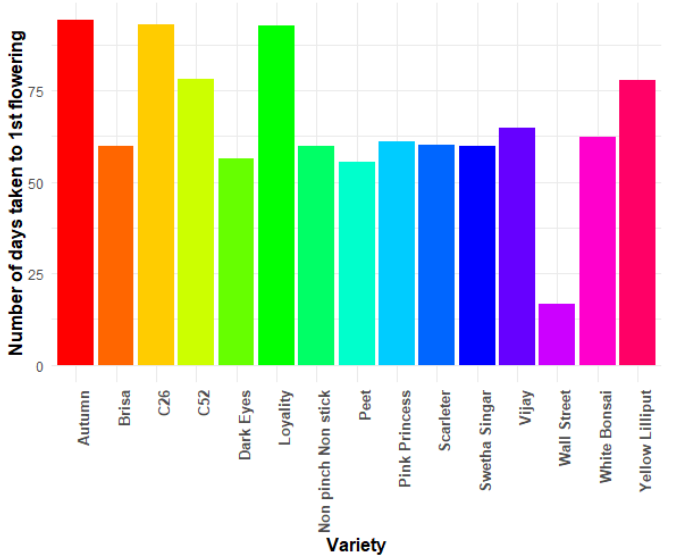

Figure 7: *Performance of different varieties of Mirabilis jalapa, number of days taken to 1st flowering.*

Number of flowers per plant

Significant variation was recorded among *Mirabilis jalapa* cultivars' performance with respect to the number of flowers per plant. The maximum number of flowers was found in V_9 Pink Princess (34), followed by V_{15} Wall Street (25) and V_8 Scarleteer (22), whereas the minimum was recorded in V_{10} Yellow Lilliput (11), Brisa V_7 (12), and V_5 Autumn (12), as shown in Figure 8. There was a significant difference in the number of flowers per plant, which can be attributed to both genetic and environmental factors. Cultivars like Pink Princess exhibited a superior genetic potential for flower production, possibly due to enhanced flower bud initiation and retention, while varieties like Yellow Lilliput, Brisa, and Autumn showed a lower flower yield, potentially due to their genetic characteristics or limiting environmental factors. This variation in flower production underscores the importance of cultivar selection for specific goals, such as ornamental purposes or yield maximization. Similar findings were reported by Laxmi *et al.* (2008), where flower production varied significantly among different cultivars of *Mirabilis jalapa*.

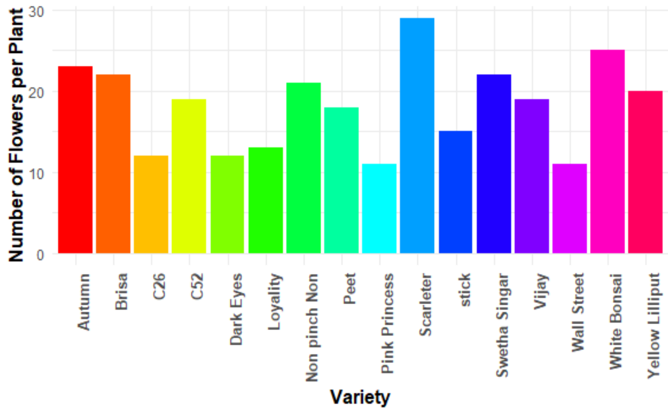

Figure 8: *Performance of different varieties of Mirabilis jalapa L. number of flowers per plant.*

Higher yield

Higher yield may be due to an increase in morphological parameters such as plant height, number of leaves, and leaf area, which likely contributed to the production of more photosynthesis. This increased photosynthetic activity results in greater accumulation of dry matter, which in turn leads to the production of more flowers per plant (Khan *et al.*, 2025). The observed differences in flower yield among cultivars could be attributed to the genetic makeup of each variety, influencing their growth patterns and overall vigor. Cultivars with superior morphological characteristics are often better at harnessing available resources for enhanced growth, leading to higher flower production. This difference in yield and growth characteristics might be influenced by genetic traits that determine the plant's capacity for vegetative growth and flower formation. Similar results were recorded in chrysanthemum by Thiripurasundari *et al.* (2021), where increased vegetative growth and leaf area were correlated with higher flower yields. These findings are illustrated in Figure 9, which showcases the relationship between growth parameters and flower production.

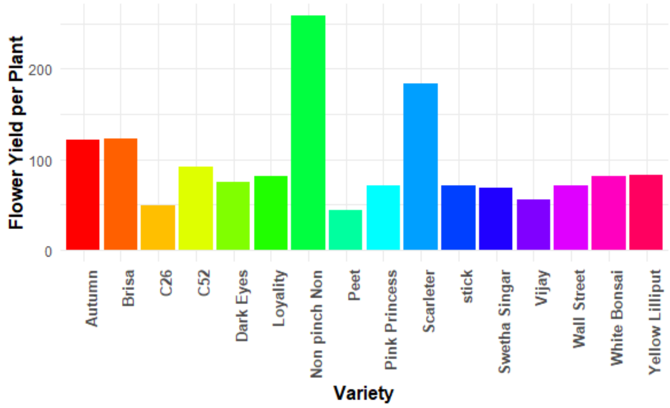

Figure 9: *Performance of different varieties of Mirabilis jalapa flower yield per plant.*

Average flower weight

Significant variation was found among the cultivars' performance with respect to the average flower weight. The highest was recorded in V_1 Non pinch Nonstick (11.4 gm), followed by V_6 C_{26} (3.63 gm) and V_3 C_{52} (3.47 gm), whereas the lowest was recorded in V_7 Brisa (1.3 gm) and V_{13} (1.3 gm), as shown in Figure 10. The difference in flower weight may be attributed to the varietal characteristics, habitat type, and the genetic makeup of the varieties, which influence their ability to produce larger flowers. Cultivars with superior genetic traits are more likely to produce heavier flowers, while environmental factors such as soil quality, water availability, and temperature can further influence this trait. Kashan *et al.* (2007) reported similar findings in chrysanthemum, where significant variations in flower weight were observed among different cultivars, attributed to both genetic and environmental factors. From the results, significant variation was also found among the cultivars' performance with respect to flower yield per plant. The highest yield was recorded in V_1 Non pinch Nonstick (258.96 gm), followed by V_9 Pink Princess (183.47 gm), and V_8 Scarleteer (122.73 gm). Conversely, the variety that gave the minimum flower yield per plant was V_{11} Vijay (44.23 gm), followed by V_7 Brisa (48.67 gm), as shown in Figure 10. The difference in flower yield per plant can be attributed to the genetic makeup, varietal characteristics, and

Links Researchers

habitat type, which play a crucial role in determining the plant's productivity. Siddique *et al.* (2018) reported similar results in Mirabilis Jalapa, where the flower yield per plant varied significantly among cultivars, influenced by both the genetic composition and environmental conditions.

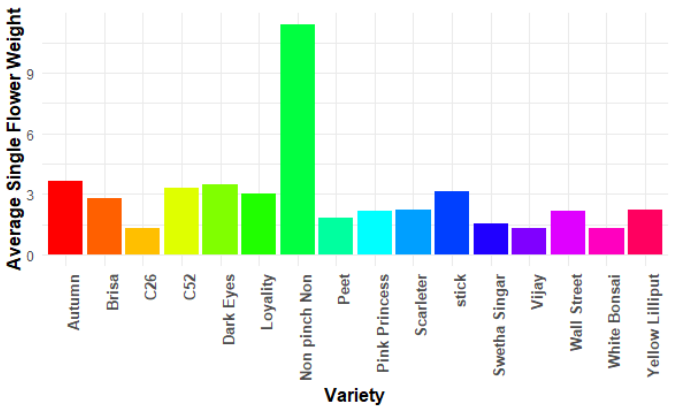

Figure 10: *Performance of different varieties of Mirabilis jalapa, average single flower weight.*

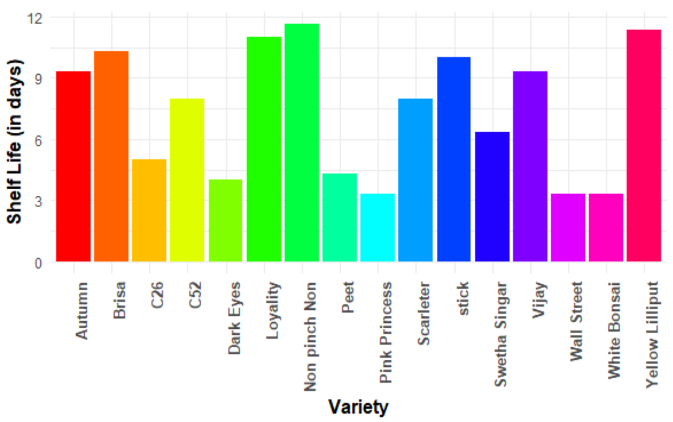

Figure 11: *Performance of different varieties of Mirabilis jalapa shelf life.*

Shelf life

Shelf life and vase life varied significantly among the cultivars of *Mirabilis jalapa* L. From the results, significant variation was observed in the cultivars' performance with respect to shelf life. Among all the varieties, the cultivar with the maximum shelf life was Non pinch Nonstick (11.66 days), which is comparable to the variety Peet (11.33 days), followed by Loyality (10.0 days). In contrast, the variety with the minimum shelf life was Wall Street (3.33 days), followed by Autumn (4.0 days), as shown in Figure 11. The difference in the shelf life of flowers may be due to factors such as the evaporation rate, transpiration rate, and other environmental factors that can influence the longevity of the flowers (Lubna *et al.*, 2025). Additionally, the genetic makeup and varietal characteristics of the cultivars, along with the habitat type, may play a crucial role in determining how long the flowers remain fresh after harvest. Joshi *et al.* (2009) and Beeralingappa (2016) reported similar findings in Mirabilis Jalapa, where significant variation in shelf life was observed among different cultivars, with genetic factors and environmental conditions contributing to the differences in longevity (Ullah *et al.*, 2025a).

Conclusion

The cultivars of *Mirabilis jalapa* exhibited a wide range of variation in growth and flowering characteristics. Significant differences were observed across all parameters studied. Among the varieties, Pink Princess demonstrated superior performance in several key traits, including the number of primary branches (13.7), number of leaves (83.44), number of flower buds per plant (44.00), and number of flowers per plant (29.00). On the other hand, non-pinch Nonstick outperformed the other cultivars in terms of plant height (35.77 cm), plant spread (22.90 cm^2), average flower weight (11.4 gm), flower yield per plant (134.15 gm), and shelf life (11.00 days), followed by C_{26} and Scarleteer. Based on the overall performance, Non-Pinch Nonstick and Pink Princess are recommended for cultivation in the Dir Lower region due to their excellent growth, flowering, and yield characteristics.

Acknowledgement

We would like to express our sincere gratitude to the Department of Agriculture, Timergara, District Dir Lower, for their valuable support in this research work and for providing the varieties of Mirabilis jalapa used in the study. We also extend our appreciation to the Department of Botany, Ghazi Umara Khan Degree College, Samarbagh (Dir Lower), for their assistance and cooperation throughout the research.

Novelty Statement

The present study offers new insights into the performance variation of *Mirabilis jalapa* L. cultivars, particularly about key growth parameters such as flower yield, flower weight, shelf life, and vase life. Significant differences were observed in traits such as the number of flowers per plant, plant height, and flower bud emergence time among the cultivars. Notably, the study highlights the genetic and environmental factors contributing to these variations, which are essential for optimizing the cultivation of *Mirabilis jalapa* for ornamental and agricultural purposes. Additionally, this research presents a comprehensive evaluation of shelf life and flower yield per plant, providing valuable data that can guide future cultivar selection and breeding efforts. The findings contribute to a deeper understanding of the growth characteristics of Mirabilis Jalapa, an area that has received limited focus in previous studies, especially with respect to the genetic factors influencing flowering time, flower bud development, and shelf life. These findings are expected to have significant implications for the selection of cultivars suited to diverse climatic conditions and ornamental uses.

Author's contribution

Shakir Ullah: Conceived and designed the study, performed the experiments, and wrote the manuscript.
Lubna Shakir: Contributed to data analysis, interpretation, and manuscript revision.
Mohammad Sohail, Iqbal Hussain, Falak Naz, and Azmat Noreen: Assisted in data collection, laboratory work, and field experiments.
Ghani Subhan: Provided critical insights on methodology and statistical analysis.
Naveen Dilawar: Contributed to manuscript review, editing, and overall supervision of the study.
All authors read and approved the final manuscript.

Funding
This research work received no external funding.

Generative AI and AI-assisted technology statement
During the preparation of this work, no generative artificial intelligence (AI) or AI-assisted technologies were used in the writing, editing, data analysis, or figure generation. All content was produced entirely by the authors.

Conflict of interest
The authors declare that there are no conflicts of interest associated with this research. The study was conducted independently, and there were no financial, personal, or professional relationships that could have influenced the results or interpretation of the findings.

References

Asif, S., Nisar, M., Ullah, S. and Naeem, M., 2025. Reviewing the impact of seed-borne mycoflora on mycotoxin accumulation: A threat to lentil genetic resources. Toxicon, 108290. https://doi.org/10.1016/j.toxicon.2025.108290

Bhattacharjee, R., Dey, U., 2003. Biofertilizer, a way towards organic agriculture: A review. Afr. J. Microbiol. Res., 8(24): 2332–2343.

Beeralingappa, 2016. Morphological characterization of chrysanthemum genotypes under central dry zone of Karnataka., M.Sc. (Horti) thesis, University of Agricultural and Horticultural Sciences, Shivamogga (India), pp. 45-74.

Bose, P., Sharma, A.K., 2002. Role of iron in controlling speciation and mobilization of arsenic in subsurface environment. Water Res., 36(19): 4916–4926.

Irshad, A., Noreen, S., Sajid, U., Jamal, M., Iqbal, M.A., Ullah, S., Sabtain, T., Ullah, S., IbañezArancibia, E., De Los Ríos-Escalante, P.R., Belkahia, H., Ben Said, M. and Swelum, A.A., 2025. Molecular identification, risk factors assessment and phylogenetic analysis of *Toxoplasma gondii* in goats from Malakand Division, Khyber Pakhtunkhwa, Pakistan. 49: 21. https://doi.org/10.1007/s11259-025-10783-z

Jamal-Uddin, R., Uddin, M.J., Hossain, M.F., Parveen, Z., 2015. Influence of brick manufacturing on phosphorus and sulfur in different agro-ecological soils of Bangladesh. Bangladesh J. Sci. Res., 29(2): 123–131.

Joshi, M., Varma, L.R. and Mau, M.M., 2009. Performance of Different varieties of chrysanthemum in respect of growth, flowering and yield under North Gujarat Conditions. Asian J. Hortic., 4(2): 292-294.

Joshi, B.K., KC, H.B., Acharya, A.K., 2010. Conservation and utilization of agricultural plant genetic resources in Nepal. In: Proc. 2nd Natl. Workshop, 22: 23.

Kashan, M., Khan, N.U., Khan, F., Ullah, Q., Rauf, A., 2007. Nitrogen use impact on nitrogen use efficiency and lint yield in zero tillage cotton. Pak. J. Agric. Res., 31(1).

Khan, S., Jan, G., Bibi, H., Sher, J., Ullah, S. and Abidullah, S., 2018. Phytochemical screening and antimicrobial activity of *Cichorium intybus* (Family: Asteraceae) and *Medicago sativa*

(Family: Fabaceae), Peshawar, Pakistan. J. Pharmacogn. Phytochem., 7(3): 603–616.

Khan, S., Jan, G., Bibi, H., Ullah, K., Gul, F. and Ullah, S., 2018a. Plants traditional medication in the arid and semi-arid zone of Tehsil Domal, District Bannu, Khyber Pakhtunkhwa, Pakistan. J. Appl. Environ. Biol. Sci., 8(8): 14–21.

Khan, S., Jan, G., Bibi, H., Ullah, K. and Ullah, S., 2018b. Antimicrobial, phytochemical, and traditional studies of selected medicinal plants in Bajaur Agency, Pakistan. Int. J. Res. Pharma. Sci., 8(2): 4–21.

Khan, M., Haris, M., Khan, M.R., Ali, I., Nasreen, N., Sohail, M., Ullah, S., 2024. Acaricidal efficacy of Melia azedarach, Olea ferruginea, and Zanthoxylum armatum against Rhipicephalus microplus from District Buner, Mardan, and Nowshera, Khyber Pakhtunkhwa, Pakistan. Asian J. Sci. Eng. Technol., 3(1): 99–114. https://doi.org/10.47264/idea.ajset/3.1.7

Khan, R., Rahid, N., Khadn, W., Shah, N., Shakir, L., Ghafoor, H., Abdullah, S., Ullah, S., 2025. Mitigation of salinity stress in maize (*Zea mays* L.) using the endophytic fungus GR7. Pak. J. Weed Sci. Res., 31(2): 151–166. https://dx.doi.org/10.17582/journal.PJWSR/2025/31.2.151.166

Kishan, S., Prasad, K.V. and Raju, D.V.S., 2008. Evaluation of chrysanthemum germplasm (*Dendranthema grandiflora* Tzvelev) in winter season under Delhi conditions. J. Ornament. Hortic., 11(1): 58-61.

Koley, K.M., Sarkar, J.M.N., 2023. Transforming rice straw into eco-friendly growing medium for microgreens: a solution for agricultural waste management. Front. Sustain. Food Syst., 9: 1556396.

Lubna, S., Sohail, M., Naz, F., Ali, S., Khan, H., Noreen, A., Subhan, G., Naveen, D., Ullah, S., 2025. Phytochemical profiling and antibacterial potential of *Morus alba* L. leaf extracts against *Salmonella typhi*. Front. Med. Health Res., 3(5): 1482–1492. Available from: https://fmhr.org/index.php/fmhr/article/vi ew/692.

Laxmi, M.S., Lakshmi, K.V., Devi, P.S., Madhuri, R.J., Aruna, S., Jyothi, K., Venkateswarlu, K., 2008. Isolation and characterization of a chlorpyrifos degrading bacterium from agricultural soil and its growth response. Afr. J. Microbiol. Res., 2(2): 26–31.

Manan, F., Ahmad, I., Asad, F., Shakir, L. and Ullah, S., 2025. Pharmacognosy, phytochemistry, and antimicrobial potential of Pteris cretica L. collected from Dir (Lower), Khyber Pakhtunkhwa. Pak. J. Weed Sci. Res., 31(2): 117-131.

Ona, A.F., Roni, M.Z.K., Ahmad, H., Jui, N.J. and Jamal Uddin, A.F.M., 2015. Study on growth and flower yield of five snowball varieties. Bangladesh Res. Publ. J., 11(3): 182-186.

Mikato, S., Urfi, F., Devi, S., Deepanshu, D., 2017. Evaluation of Chrysanthemum (Dendranthemum grandiflora) cultivars under Allahabad agro-climatic condition. Trends Biosci., 10(24): 5115–5119.

Peddi, L., Pratap, M. and Reddy, S.A., 2008. Evaluation of yellow coloured chrysanthemum (*Dendranthema grandiflora* Tzvelev) cultivars for growth, flowering and yield. Orissa J. Hortic., 36(1): 116-119.

Kumar, P., Thomas, E.J., Tray, D., 2007. 1,5-Stereocontrol in tin (IV) halide promoted reactions of 2-alkoxy-1-(2-tributylstannylethylidene) cyclohexanes with aldehydes. Tetrahedron, 63(27): 6287–6295.

Saifullah, M., Dilawar, N., Rahman, A., Ahmad, A., Usman, M., Ullah, S., Nawaz, M., 2025. Role of Rhizofungus (Aspergillus terreus) in improving biochemical and physiological parameters affected by lead stress in *Allium sativum* L. BioSci. Rev., 7(3): 71–80.

Shakir, L., Ullah, S., Suhail, M. and Ullah, R., 2023a. Phytochemical analysis, antipyretic and antifungal activities of *Solanum nigrum* L. Nat. J. Pharma. Sci., 3(2): 6–12.

Shakir, L., Asif, S., Haq, A., Haq, S., Zada, K., Said, M., Sajid, M., Ullah, S. and Ullah, R., 2023b. Phytochemical detection and medicinal studies of selected plants from war-affected areas of Khyber Pakhtunkhwa, Pakistan. J. Agric. For. Res., 2(5).

Siddiqua, A., Swarajya, L.K., Nagaraju, R. and Srinivasa, R.D., 2018. Performance of spray chrysanthemum cultivars (*Dendranthema grandiflora* Tzvelev.) in polyhouse conditions. J. Pharmacogn. Phytochem., 7(6): 1572-1575.

Singh, A.K., Singh, D.K. and Kumar, R., 2017. Evaluation of different chrysanthemum (*Chrysanthemum morifolium*) genotypes under shade net in North West Himalaya. Int. J. Pure Appl., 5(1): 980-985.

Singh, D.D., Tyagi, S., Singh, S. and Kumar, P., 2017. Studies on the performances and flower characterization of chrysanthemum (*Dendranthema grandiflora* Tzvelev) genotypes under Uttar Pradesh conditions. Adv. Res., 9(1): 1-7. https://doi.org/10.9734/AIR/2017/31467

Srilatha, V., Sunil, K.K. and Deepthi, K.Y., 2015, Evaluation of chrysanthemum (*Dendranthema grandiflora* Tzvelev) varieties in southern zone of Andhra Pradesh. Agric. Sci. Digest., 35(2): 155-157. https://doi.org/10.5958/0976-0547.2015.00029.4

Thiripurasundari, T., Devanathan, J., Selvam, K., Selvaraj, S., Ramadass, L., 2021. Isolation and characterization of drought stress tolerant plant growth promoting rhizobacter from chilli crop. Bull. Sci. Res., 3: 1–12.

Ullah, S., Jan, G., Jan, F. G., Khan, S., Khattak, M., Bibi, H. and Ihsan, M., 2018a. Phytochemical analysis, antipyretic and antifungal activities of *Cyrtomium caryotideum*. Biosci. Biotechnol. Res. Asia, 15(3): 577–589. https://doi.org/10.13005/bbra/2664

Ullah, S., Jan, G., Jan, F. G., Khan, S., Khattak, M., Bibi, H. and Ihsan, M., 2018b. Phytochemical analysis, analgesic, anti-inflammatory, and anti-bacterial activities of *Berberis lycium*. Int. J. Adv. Res., 6(7): 1150–1166. https://doi.org/10.21474/IJAR01/7470

Ullah, S., Jan, G., Gul, F., Khan, S., Husna, Sher, J. and Abidullah, S., 2018c. Phytochemistry and antibacterial activities of some selected plants of war-affected area Bajaur Agency, Pakistan. J. Pharmacogn. Phytochem., 7(3): 415–422.

Ullah, S., Jan, G., Gul, F., Khan, S., Khattak, M., Ihsan, M. and Bibi, H., 2018d. Phytochemical and nutritional analysis of selected plants of District Buner, Pakistan. Int. J. Fauna Biol. Stud., 5(3): 111–117.

Ullah, S., Jan, G., Gul, F., Israr, M., Khan, S., Khattak, M., Bibi, H. and Sher, J., 2018e. Phytochemical analysis, antipyretic, analgesic, anti-inflammatory, and antifungal activities of *Pteris quadriaurita* Retz. World J. Pharma. Pharma. Sci., 7(1): 857–876.

Ullah, S., Jan, G., Gul, F., Khan, S. and Sheer, J., 2018f. Antifungal, nutritional, and phytochemical investigation of Asplenium dalhousiae of District Dir Lower, Pakistan. J. Pharmacogn. Phytochem., 7(2): 3281–3288.

Ullah, S., Jan, G., Gul, F., Khan, S., Khattak, M., Bibi, H. and Sher, J., 2018g. Phytochemistry, anti-inflammatory and antipyretic activities of *Adiantum capillus*-veneris in Swiss albino mice. Int. J. Fauna Biol. Stud., 5(3): 19–25.

Ullah, S., Jan, G., Gul, F., Khan, S., Khattak, M., Sher, J. and Bibi, H., 2018h. Antifungal and phytochemical screening of selected medicinal plants of Malamjaba, Swat, Pakistan. Pharma Innov. J., 7(5): 176–180.

Ullah, S., Sohail, M., Niaz, K., Khan, S. and Khattak, M., 2018i. Phytochemistry and antibacterial activity of Convolvulus arvensis Linn against *Escherichia coli*. J. Chem. Biol. Phys. Sci., 8(4): 2249–1929. https://doi.org/10.24214/jcbps.B.8.4.89204

Ullah, S., Khattak, M., Abasi, F., Sohil, M., Ihsan, M. and Ullah, R., 2019a. Antifungal, nutritional and phytochemical investigation of Actiniopteris radiata of District Dir Lower, Pakistan. Int. J. Hortic. Food Sci., 1(1): 1–8. https://doi.org/10.33545/26631067.2019.v1.i2a.21

Ullah, S., Ullah, I., Naz, R., Sohil, M., Ihsan, M. and Abasi, F., 2019b. Phytochemical's screening and chromatographic separation of bioactive compound from the roots of *Berberis lyceum*. J. Biotechnol. Bioinf. Res., 1(1). https://doi.org/10.33545/26180723.2019.v2.i1a.19

Ullah, S., Ullah, I., Khan, M., Zamir, M., Khan, B. T., Naz, R., Sohil, M., Ihsan, M. and Abasi, F., 2019c. Phytochemical analysis and antibacterial activity of *Ajuga bracteosa*, *Bergenia ciliata*, and *Amaranthus viridis* from District Lower Dir, Village Maidan Banda of Khyber Pakhtunkhwa, Pakistan. Int. J. Biosci., 14(5): 403–412.

Ullah, S., Ullah, R., Ullah, F., Khan, G. Z., Shakir, L., Sardar, F. and Ullah, R., 2021. Traditional uses of plants and their role in the community development of Sheen Ghar Valley, District Lower, Khyber Pakhtunkhwa, Pakistan. Int. J. Agric. Nutr., 1(1). https://doi.org/10.33545/26646064.2021.v3.i1a.64

Ullah, S., Shakir, L. and Ullah, R., 2023a. Morphological and phytochemical study of *Cirsium arvense* from District Mardan, Pakistan. J. Bioinf. Biotechnol. Res., 1(1): 1–7. https://doi.org/10.61440/JBBR.2023.v1.01

Ullah, S. and Shakir, L., 2023. The effects of plant age on phytochemical and geographical distribution of *Euphorbia helioscopia*, (sunspurge or madwoman's milk) Euphorbiaceae from Arrang District Bajaur Pak. J. Weed Sci. Res., 29(4): 206-212.

Ullah, S., Shakir, L., Subhan, G., Sohail, M., Bilqees, R., Khan, F., Gulzar, U., Ali, S., Ullah, Z. and Ali, S., 2024a. Phytodiversity and conservation assessment of ethnobotanically significant flora in Khall Hagram Dara, Lower Dir, Khyber-Pakhtunkhwa, Pakistan. Plant Protect., 8(1): 143–162. https://doi.org/10.33804/pp.008.01.5084

Ullah, R., Rahim, F., Sajid, M., Ullah, S., Ali, S., Shakir, L. and Subhan, G., 2024b. Ethnobotanical study of Munda Khazana, District Dir Lower, Khyber Pakhtunkhwa. Pak. J. Weed Sci. Res., 30(3): 105-120.

Ullah, S., Ali, S., Shakir, L., Asif, S., Subhan, G., Sohail, M., Ali, S. and Khan, Y., 2025a. Ecological studies of different plant communities of Malasaid Hills, District Bajour, Khyber Pakhtunkhwa. Int. J. Appl. Exper. Biol., 4(4): 249-264. https://doi.org/10.56612/ijaaeb.v1i1.149

Ullah, S., Saeed, M., Sohail, M., Sajid, A., Aziz, L., Noreen, A. and Shakir, L., 2025b. Indigenous knowledge of medicinal plants used by the tribal communities of Hasham Valley, District Dir Lower, Khyber Pakhtunkhwa, Pakistan. Pak. J. Weed Sci. Res., 31(1): 37.

Ullah, S., Shakir, L., Ali, S., Subhan, G., Sohail, M., Khan, I. and Ali, S., 2025c. The nutritional analysis, phytochemical and antifungal study of *Equisetum arvense* L. from village Kharkay Pak Afghan Border District Dir Lower, Pakistan. Kashmir J. Sci., 4(1). https://doi.org/10.63147/jey5re67

Ullah, S., Shakir, L., Sohail, M., Noreen, A. and Aziz, L., 2025d. Controlling of cotton leaf worm in *Solanum nigrum* L. at District Swat (Switzerland of Pakistan) under semi-field conditions. Pak. J. Weed Sci., Res., 31(1).

Ullah, S., Lubna, S., Mohammad, S., Iqbal, H. and Ghani, S. 2025e. Integrated use of biofertilizers and zinc sulphate for enhanced growth and productivity of wheat (*Triticum aestivum* L.). Spect. Engin. Sci. 3(8): 219-232.