J. Appl. Res Plant Sci. Vol. 5(2), 259-268, **2024,** https://doi.org/10.38211/joarps.2024.05.262

Research Article

OPEN ACCESS

Available on https://www.joarps.org
Journal of Applied Research in Plant Sciences (JOARPS)
ISSN: 2708-3004 (Online), 2708-2997 (Print)

Effect of Compost on the Growth, Flowering Attributes, and Vase Life of Different Varieties of Zinnia (*Zinnia elegans*)

Muhammad Mazhar Qayyum[1], Iqbal Hussain[2*], Haider Ali[2], Tariq Saeed[3], Muhammad Umar[4], Amber Imtiaz[2], Saima Noor[2], Irfan Ali[5], Raja Muhammad Mohib Naz[4], Kazim Ali[2]

[1]Department of Horticulture, The University of Haripur, Khyber Pakhtunkhwa, Haripur Pakistan,
[2]National Institute of Genomics and Advance Biotechnology, NARC-45500, Park Road, Islamabad, Pakistan,
[3]Department of Agriculture, Muzaffarabad, Azad Jammu Kashmir,
[4]Horticulture Research Institute, National Agricultural Research Center, Islamabad, Pakistan,
[5]Department of Horticulture, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan,
*Corresponding: iqbal_abi@yahoo.com

Article Received 24-03-2023, Article Revised 12-04-2024, Article Accepted 12-05-2024.

Abstract

Zinnias originates from Mexico and has high demand in the floriculture market. The need to reduce reliance on chemical fertilizers has highlighted the importance of sustainable alternatives like organic manures. Compost application in horticulture is gaining attention as a sustainable alternative to chemical fertilizers, aiming to enhance soil health and plant growth. However, there is a limited understanding of its effects on the growth. This study investigates the effects of compost on the growth, flowering attributes, and vase life of *Zinnia elegans* to improve cultivation techniques and promote sustainable horticultural practices. The experiment used an RCBD with two factors. When they reached 3-5 true leaves, plantlets were transplanted into 12-inch pots with compost varying concentrations, including Control, 25%, 50%, and 100% with garden soil. Changing compost concentrations and zinnia varieties affected numerous factors strongly. Plant height, for instance, varied significantly, with Benary's Giant cultivar reaching the tallest (72.04 cm) under 50% compost, mirroring the stem diameter's peak at 1.01 cm with the same compost level. Compost levels and zinnia varieties also notably impacted leaf count, lateral branches, leaf area, flower count, and flower attributes like diameter and stalk length. The study also found that 50% of compost extended petal senescence survival. Compost and zinnia interaction affected the flower's fresh weight and vase life. The interaction cultivar Benary,s Giant with 50% compost in garden soil was optimal for zinnia growth and flowering. This study will provide the basics for floriculture.

Keywords: Flowering attributes; ornamental plants; organic fertilizers; vase life; sustainable horticulture.

Introduction

Zinnia (*Zinnia elegans*), a member of the Asteraceae family, its leaves are arranged in an opposite fashion and lack stalks. The flowers can either consist of a single row of petals or form a dome shape, displaying purple, lilac, and red hues. Its significance in the commercial realm is attributed to its extended shelf life, extensive promotion as a cut flower, and availability in diverse shapes and colors (Dole, 1999). Zinnia, a native flower of the Americas, originated in Central America and Mexico. In Pakistan, zinnias flourish as summer flowers, blooming from May to October. The consistent production of high-quality blooms hinges on the timely sowing of seeds, the healthy development and growth of plants, and the flowering characteristics of various cultivars (Dorgham, 2019). The key to success lies in the careful choice of zinnia cultivars, which have the potential to amplify yields through improved flower quantity and size. The cultivation of ornamental plants plays a vital role in horticultural practices, catering to both commercial markets and home gardening enthusiasts. With the increasing emphasis on sustainable agricultural practices and the need to reduce environmental impact, there is a growing interest in exploring alternative fertilization methods that promote plant health and minimize chemical inputs. Compost, derived from organic waste materials, has emerged as a promising solution due to its nutrient-rich composition and potential benefits for soil health.

Cultivars that acclimate well to the local climatic conditions effectively shield themselves from insect infestations, nutrient medium pests, and diseases, promoting robust growth that can withstand seasonal challenges (Saleem, Nafees, Farooq, & Sadaqat, 2003). An optimal growing medium should offer appropriate stability and support to the plant, function as a reservoir for water and nutrients, facilitate the diffusion of oxygen to the roots, and enable the exchange of gases between the roots and the external atmosphere surrounding the root substrate (Gola *et al.*, 2018). Utilizing compost has the potential to enhance both soil quality and crop yield (Ahouangninou *et al.*, 2022). Additionally, compost is a valuable means of capturing

CO_2 as soil carbon, effectively curbing greenhouse gas emissions within agricultural systems (Epstein, 2017; Morales *et al.*, 2016).

This study focuses on investigating the effects of compost application on the growth, flowering attributes, and vase life of *Zinnia elegans*. By evaluating the impact of compost on key parameters such as plant height, biomass production, flower quality, and post-harvest longevity, we aim to provide valuable insights into sustainable horticultural practices for ornamental plant production. Understanding the potential benefits of compost in enhancing Zinnia elegans' ornamental value not only benefits commercial growers in terms of improved product quality and market competitiveness but also promotes eco-friendly approaches for home gardeners seeking to cultivate vibrant and long-lasting floral displays. The utilization of compost in the soil led to elevated rates of C (carbon) mineralization, while the application of digestate resulted in decreased rates of C mineralization and microbial biomass C within the soil. Notably, composting exhibited a capacity to reduce the mineralization of C, thereby reducing the potential for N leaching and contributing to an augmentation in topsoil C content (Viaene *et al*., 2017). In Pakistan, the soils display inadequate aggregate stability and demonstrate deficiencies in iron, aluminum, and organic matter content. Micronutrient insufficiencies, particularly zinc, are prevalent across all rainfed regions (Rafique, Rashid, & Yasin, 1990). Various growth substrates can be employed for zinnia cultivation, where the foremost factors influencing plant growth and development encompass the physical and chemical attributes of the medium, including its structure, texture, pH, nitrogen, phosphorus, and potassium content. The composition and nutritional profile of the medium play a crucial role in promoting the production of high-quality flowering plants characterized by an increased number of blooms and larger sizes. However, extensive research regarding the application of compost on zinnia plants in Pakistan remains scarce. This study was initiated to assess the impact of diverse compost levels on zinnia growth and flowering. Specifically, the objectives were to (1) determine the optimal compost application rate for enhancing plant height and biomass, (2) assess the influence of compost on the number of flowers produced and their bloom duration, and (3) evaluate the impact of compost on the vase life of harvested flowers. Through a comprehensive analysis of compost's influence on *Zinnia elegans*, this study contributes to the broader discourse on sustainable agriculture, soil health management, and effective cultivation techniques in the ornamental plant industry. By bridging the gap between scientific research and practical applications, we aspire to encourage adopting environmentally responsible practices that support the long-term sustainability of horticultural endeavors.

Material and Methods

Study location: The study was conducted in the experimental field of the Department of Horticulture, University of Haripur, Khyber Pakhtunkhwa, Pakistan, during the summer season in the year 2023. Temperatures in Haripur, Pakistan, range from a low of 6.3°C (43.3°F) in January to a high of 37.9°C (100.2°F) in June. Humidity levels vary between 27% in June and July to 56% in August, adding a touch of moisture to the air. Rainfall patterns also fluctuate, with December seeing as little as 10mm (0.39") and August experiencing a substantial 144mm (5.67"). Rainfall spans several days, with August having the rainiest days at 18.8, while December has the fewest at 2.5. Daylight hours increase gradually from 10.2 hours in January to 14.4 hours in June, providing ample daylight for activities. Sunshine hours generally exceed 7 hours daily, peaking at 12 hours in June and July. Visibility averages 10km (6.2 mi) annually, offering clear views. Wind speeds range from 7.9km/h (4.9mph) to 10.8km/h (6.7mph), and cloud cover remains below 31%, contributing to clear skies and pleasant weather conditions.

Experimental design and treatments: The research was carried out using a Randomized Complete Block Design (RCBD) that encompassed two factors. The experimental setup consisted of fifteen treatment combinations, with each treatment being randomly assigned within each replication, and each treatment was replicated three times. Seeds of the Zinnia varieties, namely Dreamland Mix, Benary's Giant, and Profusion Double, were procured from Awan Seeds Stores on Murree Road in Rawalpindi and the varietal confirmation was done through proper molecular analysis. These seeds were sown in early May 2023 and subsequently transplanted to the experimental site in mid-June 2023, upon reaching the 3-5 true leaves stage. For optimal nutrient availability and support, the Zinnia plantlets were transplanted into 12-inch pots. The implementation of various cultural practices, including weeding, irrigation, plant protection measures, and fertilization, was uniformly carried out. Poultry compost (1.8% N; 1.0% P; and 0.8% K) was mixed with garden soil at varying concentrations, including Control, 25%, 50%, and 100% with garden soil, and then filled into the pots. The Zinnia varieties constituted Factor A, while the levels of compost comprised Factor B. Throughout the experiment, all potential combinations (15) were thoroughly studied, and mean tables were formulated to facilitate the interpretation of the obtained results. The observations on various parameters of vegetative growth and flowering attributes were studied. Five plants selected randomly were tagged and used for recording the desired parameters.

Study parameters: The study assessed various growth parameters, including plant height (cm), stem diameter (cm), number of leaves per plant, length of branches (cm), number of branches, and leaf area (cm^2). Additionally, flowering parameters such as days to

flowering, number of flowers per plant, flower stalk length (cm), flower diameter (cm), flower fresh weight (g), and vase life were recorded throughout the experimental period.

Data analysis: Statistical analysis was conducted using the RCBD with two factors. The data collected were analyzed using the statistical package Statistics 8.1 and further validated by the SPSS tool, following the relevant procedures. The ANOVA was used to perceive the significance of the treatments and LSD was used to see the difference between means (Levy & Gómez, 1985).

Results

Growth Parameters: The data analysis indicated that different compost levels, zinnia varieties, and their interaction had a significant effect on the plant height of zinnia (Figure 1A). The most heightened plants (72.04 cm) of Benary,s Giant cultivar were observed where compost (50 %) was applied, followed by (62.05 cm) of Profusion cultivar in compost (50 %) and the smallest plants (37.03, 36.29, and 37.53 cm) respectively were observed in 100 % treatment of compost all varieties respectively. The plants exhibited the greatest plant diameter (1.01 cm) when treated with a 50% compost application (Figure 1B). This was followed by diameters of 0.9 cm in cases of both 25% and 75% compost applications. Conversely, the smallest plant diameters (0.87 and 0.83 cm) were observed in the control and 100 % compost treatment. The most substantial leaf count per plant (71.84 and 70.92) was recorded in both the Benary's Giant and Profusion varieties, both of which received a 50% compost application (Figure 1C). Following this, the Dreamland cultivar exhibited a leaf count of 65.16. Conversely, the 100 % compost-treated plants displayed the lowest (30.67 and 31.22) leaf count of Dreamland and Profusion varieties.

The longest branches (31.2 and 29.43 cm) were found in both the Benary's Giant and Profusion varieties, where 50% compost was used (Figure 1D). Next, the Dreamland cultivar had branches that were (27.89 cm) long under the 50% compost treatment. On the other hand, the plants without any treatment had the shortest branches (15.45 and 15.65 cm) Profusion and Dreamland varieties. The Benary's Giant cultivar exhibited the most substantial branch count (7.67) under the application of 50% compost. Following this, the Profusion cultivar displayed branches numbering (7.1) under the same 50% compost treatment. In contrast, the untreated plants demonstrated the lowest branch counts (2.78) for the Dreamland cultivar (Figure 1E). The greatest leaf area (27.35 and 26.46 cm^2) was observed in both the Benary's Giant and Profusion varieties, following the utilization of 50% compost. Subsequently, the Dreamland cultivar exhibited a leaf area of (22.45 cm^2) within the context of the 50% compost treatment. Conversely, plants that received 100 % compost treatment displayed the smallest leaf area (12.12 and 12.45 cm^2) for the Dreamland and Profusion varieties (Figure 1F).

Flowering Parameters: There was a significant impact on the number of flowers per zinnia plant exerted by varying compost levels, distinct zinnia varieties, and their combined interaction (Figure 2A). The most substantial flower count per plant (10.98) was achieved by the Benary's Giant cultivar, which received a 50% compost application. Following this, a flower count of (10.2) was exhibited by the Profusion cultivar under the 50% compost treatment (Figure 2B). Conversely, the lowest flower count (4.89) for the Dreamland cultivar was observed in plants treated with 100% compost.

The Benary's Giant and Profusion varieties, treated with 50% compost, achieved the most substantial flower stalk lengths (7.5 and 7.3 cm). Subsequently, the Dreamland cultivar exhibited a flower stalk length of (6.58 cm) under the same 50% compost treatment. On the other hand, the lowest flower stalk lengths were observed in plants subjected to the control and 100% compost treatments across all varieties (Figure 2C). The most substantial flower diameter (6.37 cm) was achieved by the Benary's Giant cultivar, which received a 50% compost treatment. This was followed by the Profusion cultivar, which exhibited a flower diameter of (5.93 cm) under the same 50% compost treatment. On the other hand, the lowest flower diameters were observed in plants subjected to the control and 100% compost treatments across all varieties (Figure 2D). The Benary's Giant cultivar exhibited the shortest time to initiate flowering, occurring at 48.01 days, followed by the Profusion cultivar at 50.01 days, and the Dreamland cultivar at 51.14 days. Conversely, the 50% compost treatment led to the quickest flower bud initiation, taking 42.16 days, with the 75% compost treatment following suit. The longest interval (54.2 days) for flower bud initiation was associated with the 100% compost treatment. The plants demonstrated an extended period to reach 50% petal senescence (10.86 days) when subjected to a 50% compost application. Following this, a similar period (9.8 days) to 50% petal senescence was observed in both the 25% compost and control treatments. In contrast, the 100% compost treatment led to the shortest interval to achieve 50% petal senescence (7.59 days). The most substantial flower fresh weight (3.24 g) was attained by the Benary's Giant cultivar, which was subjected to a 50% compost treatment. Following this, both the Profusion and Dreamland varieties exhibited flower fresh weights of (3.15 g and 2.98 g) under the same 50% compost treatment. Conversely, the lowest flower fresh weights (1.81 g, 1.8 g, and 1.7 g) were noted in plants treated with 100% compost across all three varieties, respectively (Figure 2E). The Benary's Giant and Profusion varieties achieved the longest vase life (27.17 and 26.05 days) under the influence of a 50% compost treatment. Subsequently, the Dreamland cultivar displayed a vase life of (22.73 days) within the

same 50% compost treatment. Conversely, the shortest vase lives (13.92 days, 13.38 days, and 13.37 days) were observed in plants subjected to 100% compost treatments across all three varieties, respectively (Figure 2F).

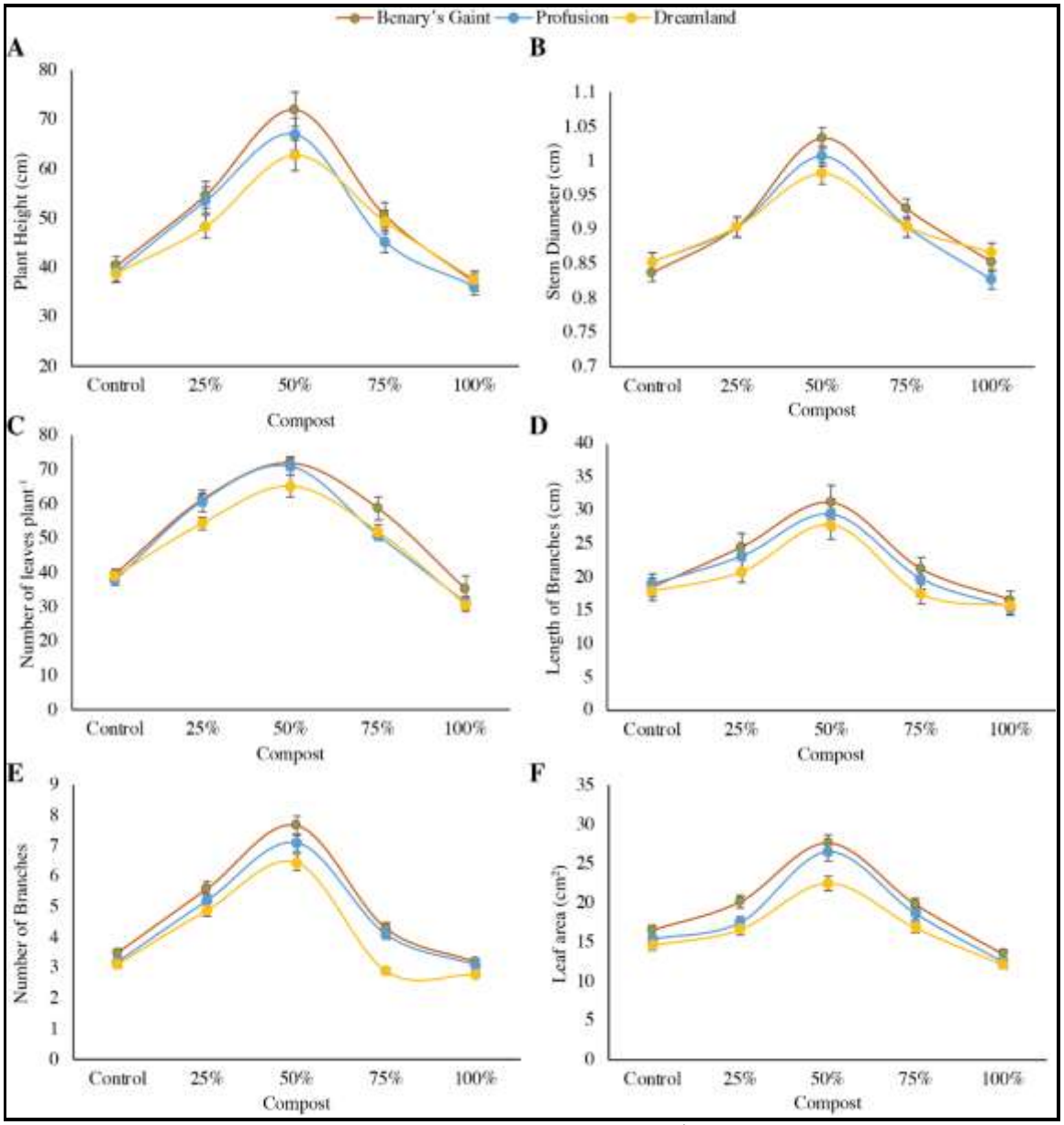

Figure 1. Plant height (cm, A), stem diameter (cm, B), Number of leaves plant^{-1} (C), Length of branches (cm, D), Number of branches (E), and leaf area (cm^{-2}, F) as affected by application of compost. Bars showed the standard errors (n=3).

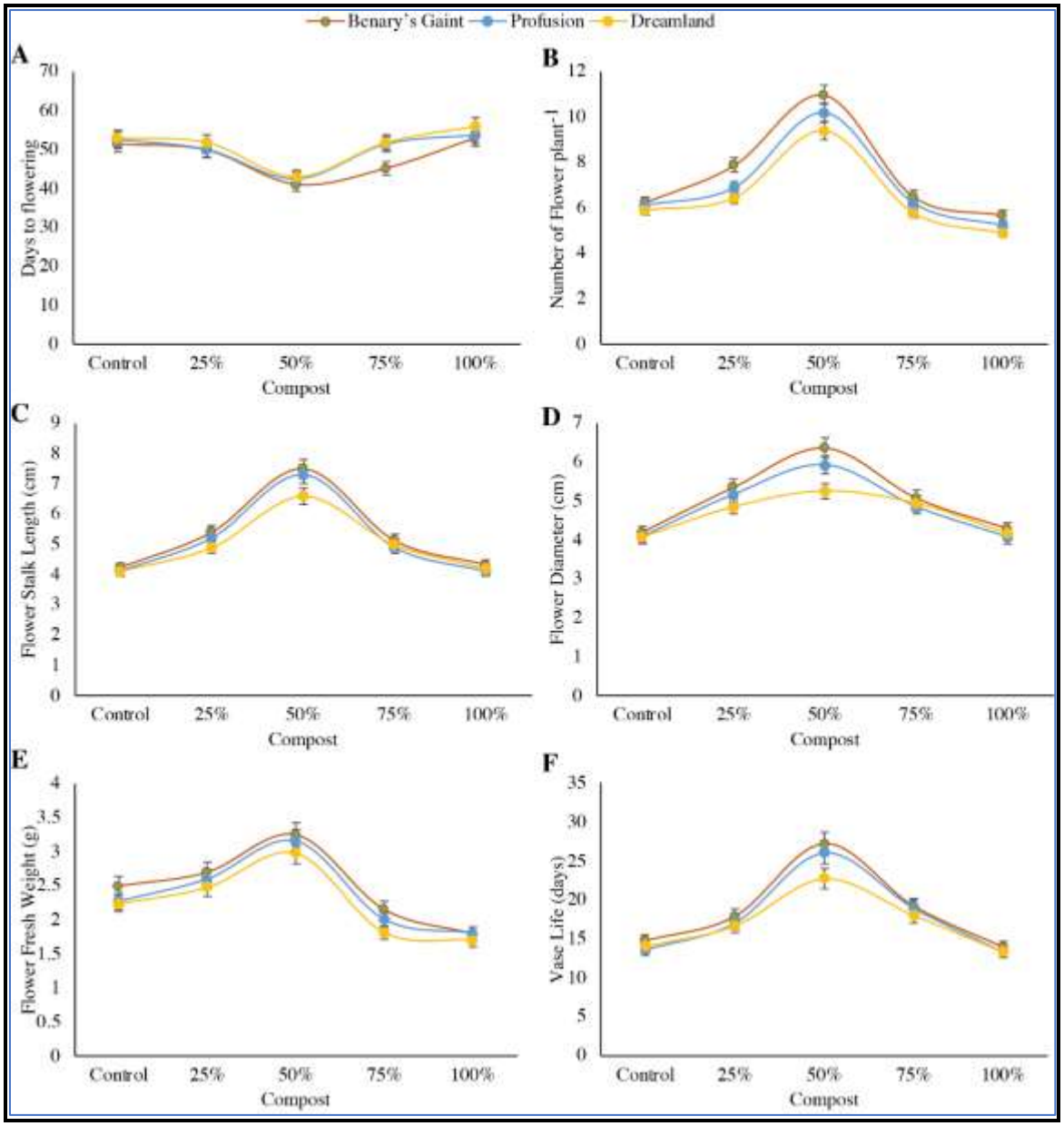

Figure 2. Days to flowering (A), Number of flowers plant^{-1} (B), Flower stalk length (cm, C), Flower diameter (cm, D), Flower fresh weight (g, E), and Vase life (F) as affected by the application of compost. Bars showed the standard errors (n=3).

Principal Component Analysis: It is a technique used for showing more complex data more effortlessly. The results of PCA showed that the first two PCs were significant and contributed 96.2% cumulatively (Figure 3). PC1 showed 92.9% and PC2 showed 3.3% of the total variation (Figure 3A). All the treatments and traits were spread across the quadrants. This indicates the variability among the varieties, treatments, and traits under study. All the traits showed strong associations among themselves except NDTF (Figure 3B).

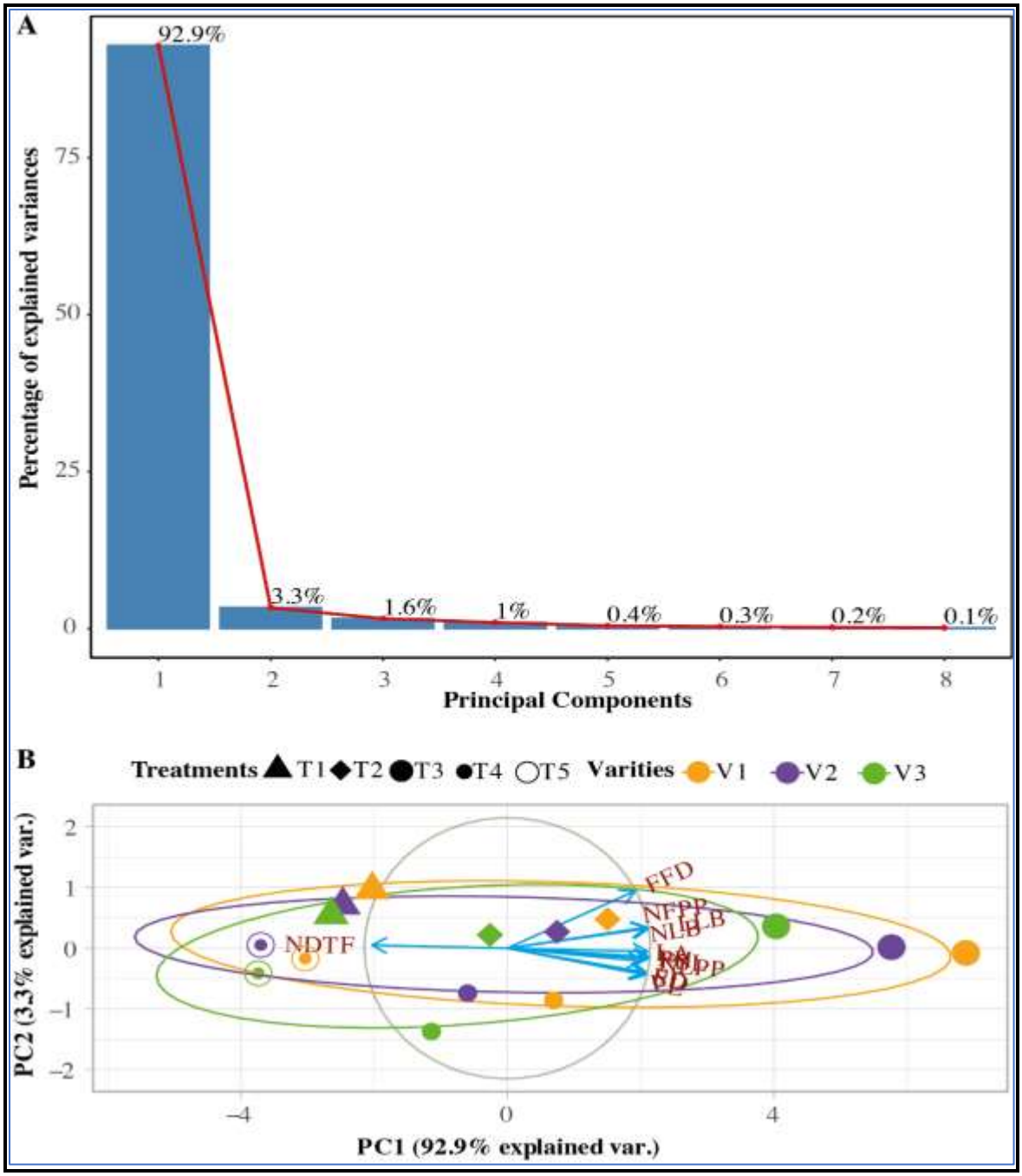

Figure 3. Principal component analysis (PCA) among growth and flowering parameters. Plant height (cm, PH), stem diameter (cm, SD), Number of leaves plant^{-1} (NLPP), Length of branches (cm, LLB), Number of branches (NLB), and leaf area (cm^{-2}, LA), Days to flowering (NDTF), Number of flowers plant^{-1} (NFPP), Flower stalk length (cm, FSL), Flower diameter (cm, FD), Flower fresh weight (g, FFW), and Vase life (VL). T1 = Control, T2 = 25%, T3 = 50%, T4 = 75%, and T5 = 100% with garden soil.

Association analysis: For any breeding program, it is very important to understand the nature of traits. In which traits they integrate and show cumulative response. In this study, we also check the association among the traits. Plant height (PH) showed a strong and significant association with FSL, SD, LLB, VL, FD, and NLPP. PH also showed a significant but negative association with NDTF (Figure 4). Similarly, all the study traits were negatively associated with NDTF.

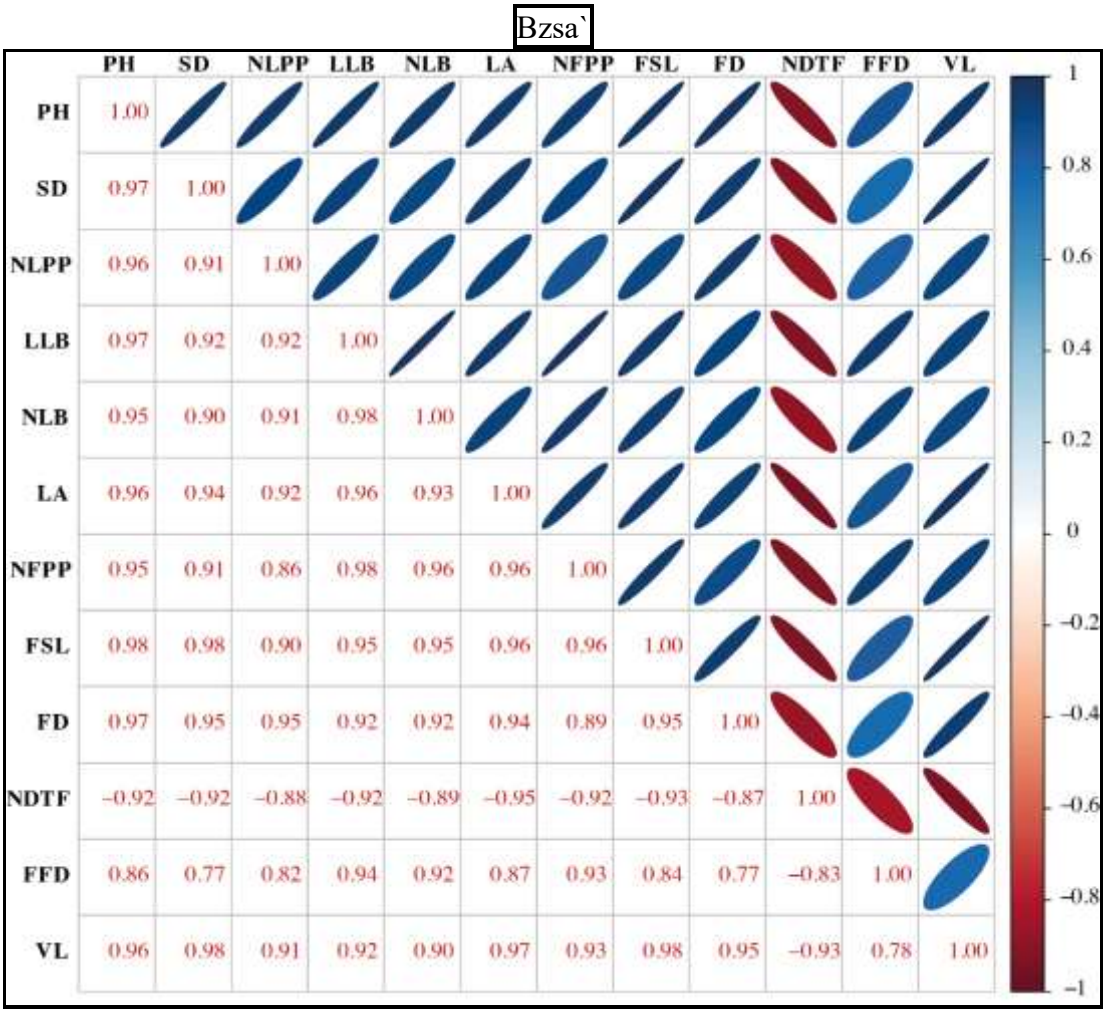

Figure 4. Correlation among growth and flowering parameters. Plant height (cm, PH), stem diameter (cm, SD), Number of leaves plant^{-1} (NLPP), Length of branches (cm, LLB), Number of branches (NLB), and leaf area (cm^{-2}, LA), Days to flowering (NDTF), Number of flowers plant^{-1} (NFPP), Flower stalk length (cm, FSL), Flower diameter (cm, FD), Flower fresh weight (g, FFW), and Vase life (VL).

Discussion

The enhanced growth characteristics of standard zinnia plants resulting from compost application are attributed to improved organic matter decomposition and nutrient mineralization. Furthermore, compost is believed to directly influence plants through hormonal mechanisms and indirectly affect soil microorganisms, leading to enhanced nutrient uptake dynamics and improved soil properties, ultimately promoting plant growth and productivity (Ojo, Olowoake, & Obembe, 2014; Ouni, Ghnaya, Montemurro, Abdelly, & Lakhdar, 2014). The results are consistent with the research conducted by (Ahmed, Khan, Hamid, & Hussain, 2004) and (Turhan, Kahriman, Egesel, & Gul, 2007), who discovered that the optimal growth medium for saffron was a mixture comprising compost applied both above and below the corms. These findings were corroborated by (Yusef, 1997), those who observed that the application of organic fertilizers yielded the most favorable outcomes for the growth of annual flowers such as petunia, snapdragon, and marigold resulting in increased plant height. These outcomes find support in the earlier studies, which underscored the significant influence of varied growing compost media on Hippeastrum vittatum's vegetative growth characteristics, flowering parameters, bulb productivity, and leaf chemical composition parameters (El-Naggar & El-Nasharty, 2009).

Compost plays a pivotal role in facilitating the proper growth of plant species. Properly chosen planting varieties resulted in taller and well-structured plants with an adequate number of leaves. Moreover, the number of leaves in zinnia plants showed a significant increase under suitable compost concentrations with higher nutrient availability (Nair & Bharathi, 2015). The nutrient-rich environment created by suitable compost concentrations in the medium results in improved performance of zinnia plants compared to both the control and higher concentrations. It was also observed that an optimal compost concentration with sufficient nutrient availability ensures an enhanced photosynthetic process, leading to an increase in photosynthates and the accumulation of carbohydrates that ultimately facilitate plant growth (Alidoust, Torkashvand, & Khomami, 2012). Additionally, the maximum length of lateral branches was found under

the medium where compost was incorporated (Rakesh Kumar, Singh, Tomar, & Gupta, 2022). These findings correspond with the results documented in prior research that investigated the utilization of compost on calendula plants. The connections established between these two studies indicate a recurring pattern in which the application of compost yields a beneficial influence on plant growth and development. This alignment underscores the consistent and positive impact of compost application across different plant species (Rakesh Kumar *et al.*, 2022).

Compost comprises essential nutrients such as organic matter and mineral nutrients (Ahmad, Aziz, Ullah, & Raza, 2022). When compost is applied, it stimulates root growth and enhances the plant's ability to absorb nutrients. This leads to augmented vegetative growth and the development of additional side branches (Pane, Palese, Celano, & Zaccardelli, 2014). The incorporation of compost also leads to notable improvements in both the chemical and physical properties of the soil, though these effects are more pronounced at lower application rates. The addition of compost increases the concentrations of essential plant nutrients, particularly phosphorus (P) and potassium (K) (Ho *et al.*, 2022). The increased leaf area can be attributed to the enriched nutrient availability facilitated by compost application. This heightened nutrient availability enhances carbohydrate accumulation, which in turn supports the growth and development of roses (Younis *et al.*, 2015). The length of the root holds significant importance in determining the overall yield. Longer roots are a result of plants exhibiting superior growth and increased carbohydrate allocation to the underground portions. These findings align with research indicating that the application of compost leads to increased root growth (Sultana, Kashem, & Mollah, 2015). Taller plants were observed to develop under optimal compost conditions, which might be attributed to the mitigated effects of acidity and potential harmfulness associated with higher compost concentrations (Altaf, Younis, Ramzan, & Ramzan, 2021). The findings of correlation and PCA also showed a strong association among the study parameters, genotypes, and compost concentrations.

Zinnia plants grown in a suitable nutrient-rich medium also exhibited taller flower stalks, these findings are in line with the results on chrysanthemums (Padhiyar, Bhatt, Desai, Patel, & Chavda, 2017). The interaction between assimilated availability and water potential influences this process. The size of a flower is contingent upon both the quantity and dimensions of floral organs, as well as the floral meristem's dimensions (Filipović *et al.*, 2023). Consequently, flower size may experience enhancement owing to the enlarged leaf area and spike length observed in the respective treatment. Our findings validate earlier observations that highlight the advantageous impact of compost on floral attributes in cut flowers (Aydinsakir, Unlu, Yilmaz, & Ari, 2009). Flower opening is an intricate, precisely sequenced process encompassing various growth and development aspects like cell division, differentiation, cellular expansion, and gene expression. The quality of cut flowers is gauged by their ability to open in a vase; thus, flower opening is essential for their visual appeal. Nevertheless, premature senescence isn't desirable as it hastens the flower's progression towards its final stage (Kishimoto, 2022). The opening of a floral bud initiates a strictly regulated genetic program, prompting programmed cell death (PCD) in the petals. Once triggered, this PCD process is irrevocable in floral tissues. The overall flower growth dictates its fading. Pre-harvest growth predicts the flower spike's postharvest longevity, with healthier spikes enduring longer fading times, while weaker spikes open their florets more rapidly (Gupta & Dubey, 2018). The fresh weight of a cut flower plays a crucial role in determining both its vase life and overall freshness, making it a significant quality parameter. The introduction of a nutrient-rich medium, combined with compost application, has the potential to augment the fresh weight of flowers. This improvement could be attributed to heightened photosynthetic activity, resulting in the accumulation of photosynthates, which subsequently exert a positive impact (Rahmani, Karimi, & Moradi, 2020). The effective photosynthesis process likely facilitated greater carbohydrate storage within the plants. The observed increase in fresh weight under suitable conditions can potentially be linked to heightened carbonic anhydrase activity (Ravi Kumar, Yadav, Shankar, Sharma, & Rani, 2022). Morphological and physiological parameters preharvest, as well as at the time of harvest, significantly influence the subsequent vase life. A healthier spike, characterized by attributes like length, diameter, fresh weight, and flower size, is pivotal for extending the vase's life (Karimian, Nazari, & Samadi, 2021). The current study establishes a positive correlation between the vase life and these morphological and physiological parameters.

Conclusions

The practical implications of this study are significant for horticultural practices and commercial production strategies. The findings of current study suggest that incorporating compost into cultivation techniques for *Zinnia elegans* can lead to improved plant growth, enhanced flower quality, and extended vase life. For commercial growers, this translates into potential cost savings on chemical fertilizers and increased marketability of their products due to higher-quality blooms. Home gardeners can benefit from sustainable practices that promote healthier plants and longer-lasting flowers. Overall, our results advocate for the adoption of compost as a viable and eco-friendly approach in horticulture, aligning with the industry's growing emphasis on sustainable production methods. This research provides information regarding different levels of compost application on zinnia varieties. It is concluded from the experimental results that the application of 50 % compost with garden soil had

shown significant results in most of the growth and flowering parameters of zinnia varieties. The diversity found in varieties and the Binary's Giant followed by the Profusion cultivar significantly performed better in most growth and flowering attributes. The compost application at the rate of 50 % compost with garden soil should be used to obtain the ideal performance of Binary's Giant zinnia cultivar regarding vegetative and reproductive attributes under the climatic conditions of Haripur. Further experiments are also recommended on micronutrients, growth regulators, and time of application on other different flower cultivars.

Conflicts of Interest

The authors declare no conflict of interest**.**

References

Ahmad, S., Aziz, A. U. R., Ullah, A., & Raza, M. A. (2022). Effect of vermicompost and organic matter in enhancing wheat tolerance against drought stress. *International Journal of Agriculture and Biosciences*, ***11***(3), 165-167.

Ahmed, M., Khan, M. F., Hamid, A., & Hussain, A. (2004). Effect of urea, DAP and FYM on growth and flowering of dahlia (Dahlia variabilis). *International Journal of Agriculture and Biology*, ***6***(2), 393-395.

Ahouangninou, C., Hounmalon, G. A., Zandjanakou-Tachin, M., Mensah, A., Osse, R., Tanmakpi, J., . . . Edorh, P. (2022). Effect of compost and association (Solanum+ amaranth) on pests and productivity of Solanum macrocarpon.

Alidoust, M., Torkashvand, A. M., & Khomami, A. M. (2012). The effect of growth medium of peanut shelles compost and nutrient solution on the growth of Dracaena. *Annals of Biological Research*, ***3***(2), 789-794.

Altaf, K., Younis, A., Ramzan, Y., & Ramzan, F. (2021). Effect of composition of agricultural wastes and biochar as a growing media on the growth of potted Stock (Matthiola incana) and Geranium (Pelargonium spp). *Journal of Plant Nutrition*, ***44***(7), 919-930.

Aydinsakir, K., Unlu, A., Yilmaz, S., & Ari, N. (2009). The effects of compost applications on yield and quality characteristics of Anemone coronaria L. cv.'Red Meron'. *Acta Horticulturae*, ***807***, 359-364.

Dole, H. (1999). Zinnias: Colorful, butterfly-approved. *Butterfly Gardeners Quarterly. BGQ, PO Box*, ***30931***.

Dorgham, A. H. (2019). Vegetative growth, flower quality and seed production of Zinnia elegans cultivars in response to foliar application of potassium from different sources. *Middle East Journal of Agriculture Research*, ***8***(4), 1306-1318.

El-Naggar, A., & El-Nasharty, A. (2009). Effect of growing media and mineral fertilization on growth, flowering, bulbs productivity and chemical constituents of Hippeastrum vittatum, Herb. *Agric. & Environ. Sci*, ***6***(3), 360-371.

Epstein, E. (2017). *The science of composting*: CRC press.

Filipović, V., Ugrenović, V., Popović, V., Dimitrijević, S., Popović, S., Aćimović, M., . . . Pezo, L. (2023). Productivity and flower quality of different pot marigold (Calendula officinalis L.) varieties on the compost produced from medicinal plant waste. *Industrial Crops and Products*, ***192***, 116093.

Gola, A. Q., Jakhro, M. I., Habib, M., Ahmed, S., Badini, M. A., Shahwani, M. W., . . . Shah, S. I. A. (2018). 2. Influence of various growing media on growth and flowering of zinnia (Zinnia elegans) Dreamland. *Pure and Applied Biology (PAB)*, ***7***(3), 946-954.

Gupta, J., & Dubey, R. K. (2018). Factors affecting post-harvest life of flower crops. *International Journal of Current Microbiology and Applied Sciences*, ***7***(1), 548-557.

Ho, T. T. K., Le, T. H., Tran, C.-S., Nguyen, P.-T., Thai, V.-N., & Bui, X.-T. (2022). Compost to improve sustainable soil cultivation and crop productivity. *Case Studies in Chemical and Environmental Engineering*, ***6***, 100211.

Karimian, N., Nazari, F., & Samadi, S. (2021). Morphological and biochemical properties, leaf nutrient content, and vase life of tuberose (Polianthes tuberosa L.) affected by root or foliar applications of silicon (Si) and silicon nanoparticles (SiNPs). *Journal of Plant Growth Regulation*, ***40***, 2221-2235.

Kishimoto, K. (2022). Effect of Temperature on Scent Emission from Carnation Cut Flowers. *Japan Agricultural Research Quarterly: JARQ*, ***56***(2), 163-170.

Kumar, R., Singh, A. K., Tomar, K., & Gupta, A. K. (2022). Effects of Different Media on Growth and Flowering Traits of Calendula Officinalis L. *Bangladesh Journal of Botany*, ***51***(3), 417-424.

Kumar, R., Yadav, M. K., Shankar, B. A., Sharma, S., & Rani, R. (2022). Effect of different chemicals to enhance vase life of tuberose (Polianthes tuberosa L.) cut flowers. *International Journal of Agricultural and Statistical Sciences*, ***18***(1), 995-1002.

Levy, A. V., & Gómez, S. (1985). The tunneling method applied to global optimization. *Numerical optimization*, ***1981***, 213-244.

Morales, A. B., Bustamante, M. A., Marhuenda-Egea, F. C., Moral, R., Ros, M., & Pascual, J. A. (2016). Agri-food sludge management using different co-composting strategies: study of the added value of the composts obtained. *Journal of cleaner production*, ***121***, 186-197.

Nair, S. A., & Bharathi, T. U. (2015). Influence of potting media composition on pot mum production. *The Bioscan*, ***10***(1), 73-76.

Ojo, J. A., Olowoake, A. A., & Obembe, A. (2014). Efficacy of organomineral fertilizer and un-amended compost on the growth and yield of watermelon (Citrullus lanatus Thumb) in Ilorin Southern Guinea Savanna zone of Nigeria. *International Journal of Recycling of Organic Waste in Agriculture*, ***3***, 121-125.

Ouni, Y., Ghnaya, T., Montemurro, F., Abdelly, C., & Lakhdar, A. (2014). The role of humic substances in mitigating the harmful effects of soil salinity and improve plant productivity. *International Journal of Plant Production*, ***8***(3), 353-374.

Padhiyar, B., Bhatt, D. S., Desai, K., Patel, V., & Chavda, J. (2017). Influence of different potting media on growth and flowering of pot chrysanthem var. ajina purple. *Int. J. Chem. Stud*, ***5***, 1667-1669.

Pane, C., Palese, A. M., Celano, G., & Zaccardelli, M. (2014). Effects of compost tea treatments on productivity of lettuce and kohlrabi systems under organic cropping management. *Italian Journal of Agronomy*, ***9***(3), 153-156.

Rafique, E., Rashid, A., & Yasin, M. (1990). Extent and severity of micronutrient status in soils of Jhelum district. *unpublished) National Agriculture Research Centre (NARC), Islamabad, Pakistan*.

Rahmani, F., Karimi, M., & Moradi, H. (2020). Effect of Wood Chips Compost and Humic Acid on Growth, Flowering and Vase Life of Lily (Longiflorum× Asiatic) Cv. Nashville. *Journal of Agricultural Science and Sustainable Production*, ***30***(3), 185-202.

Saleem, B., Nafees, M., Farooq, M., & Sadaqat, H. (2003). Genetic variability estimation for growth characteristics in Zinnia elegans Jacq Across different population densities. *International Journal of Agriculture & Biology*, ***5***(4), 496-498.

Sultana, S., Kashem, M. A., & Mollah, A. K. (2015). Comparative assessment of cow manure vermicompost and NPK fertilizers and on the growth and production of zinnia (Zinnia elegans) flower. *Open Journal of Soil Science*, ***5***(09), 193.

Turhan, H., Kahriman, F., Egesel, C. O., & Gul, M. K. (2007). The effects of different growing media on flowering and corm formation of saffron (Crocus sativus L.). *African Journal of Biotechnology*, ***6***(20).

Viaene, J., Agneessens, L., Capito, C., Ameloot, N., Reubens, B., Willekens, K., . . . De Neve, S. (2017). Co-ensiling, co-composting and anaerobic co-digestion of vegetable crop residues: Product stability and effect on soil carbon and nitrogen dynamics. *Scientia Horticulturae*, ***220***, 214-225.

Younis, A., Riaz, A., Javaid, F., Ahsan, M., Tariq, U., Aslam, S., & Majeed, N. (2015). Influence of various growing substrates on growth and flowering of potted miniature rose cultivar ‘‘Baby Boomer’’. *Curr Sci Perspect*, ***1***, 16-21.

Yusef, S. (1997). Influence of organic and inorganic fertilization on the growth of some annual flowers. *Agric Res Center King Saud Univ*, ***70***, 5-2.1.