World Journal of Environmental Biosciences

Available Online at: **www.environmentaljournals.org**

Volume 8, Issue 4: 12-18

ISSN 2277- 8047

Evaluation of Nutrient Uptake and Flowering of Gerbera in Response of Various Growing Media

Mohammad Ali Khalaj[1]*, Suresh Kumar P.[2], Hamid Reza Roosta[3]

[1] Scientific Board Member of Ornamental Plants Research Center (OPRC), HSIR, AREEO, Iran
[2] Senior Scientist, Fruit Science, National Institute of Abiotic Stress Management, Baramati, Maharashtra, India
[3] Dept. of Horticulture, Faculty of Agriculture, Vali-e-Asr University of Rafsanjan, Rafsanjan, Iran.

ABSTRACT

This experiment was performed to evaluate the effect of different growing media on nutrient uptake and yield of gerbera flower under soilless culture system. The experiment was performed using 10 treatments as follows: fine sand, peat+fine sand (25%+75%), peat+fine sand (50%+50%), perlite+peat (75%+25%), perlite+peat (50%+50%), perlite+peat (25%+75%), perlite+peat+expanded clay (25%+70%+5%), perlite+peat+ expanded clay (50%+25%+25%), perlite+peat+expanded clay (25%+50%+25%), peat+expanded clay (50%+50%), in a randomized complete block design with three replications. The results indicated that planting beds had a statistically significant effect on the morphological characteristics and macro and micronutrients in plants. Media containing perlite (25%) + peat (70%) + expanded clay (5%) led to higher flower number (207 m^2/year), flower disk diameter (12.4 cm), shoot diameter (0.8 cm), shoot neck diameter (0.58 cm), flower height (54.5 cm), and vase life (11.6 days). Plants growing in this treatment, showed the highest levels of mineral nutrients in their leaves, as concentration of nitrogen, phosphorus, and potassium were 4.17, 0.8, and 4.34 percent, respectively and micronutrients concentration such as iron, manganese, zinc, copper, and boron were 155.73, 194.83, 148.56, 44.92, and 51.5 mg kg^{-1} leaf dry weight, respectively. Therefore, it is concluded that good production was related to higher nutrients uptake from the growing media and can be proposed as a media for commercial gerbera planting.

Keywords: *Gerbera, Soilless culture, Macronutrient, Media*

Corresponding author: Mohammad Ali Khalaj
e-mail ✉ khalaj56 @ yahoo.com
Received: 19 May 2019
Accepted: 25 October 2019

1. INTRODUCTION

Gerbera (*Gerbera jamesonii* L.) belonging to the Asteraceae family, is an herbaceous plant, native to Africa and Asia that grows in mountainous climates and are most widely used for cut flowers, pot crops, and bedding plants (Khalaj *et al.*, 2017). Robert Jameson, a Scotsman, first discovered gerbera daisies near Barberton in the Transvaal area of South Africa in 1880 (Mustapić-Karlić *et al.*, 2012). These days, various soilless media are used in horticulture for plant propagation, growing seedlings, and ornamental plant production (Roosta *et al.*, 2016). Different planting media are used to grow gerbera around the world including sand, pumice, zeolite, composted cow manure, organic substrates, expanded clay, coconut fiber (coco peat), vermiculite, rock wool, perlite, etc. (Fakhri *et al.*, 1995; Maloupa *et al.* 1996; Khalaj, 2007). Soilless cultures are successfully used for several decades to reduce cost and intensify production (Maloupa *et al.*, 1993; Bontemps, 1999; Malorgio et al, 1994).

Peat is the most common substrate for the production of potted plants in the nurseries and forms a considerable part of materials used to grow potted plants (Ribeiro *et al.*, 2007; Marfa *et al.*, 2002). In recent years, coco peat (=coconut mesocarp or coir dust) is considered as a renewable sphagnum peat substitute for use in horticultural and especially ornamental plants (Yau and Murphy, 1998; Pickering, 1997; Mascecarini, 1998).

Perlite, an aluminosilicate of volcanic origin, is rather inert (low buffering and cation exchange capacities of 0–1 mg.L^{-1}) has been widely used in soilless cultures. It has a closed cellular structure with the majority of water which is superficially retained and slowly released at relatively low tension, providing great rhizosphere aeration and medium drainage. Thus, it needs frequent irrigation to prevent fast developing water stress (Maloupa *et al.*, 1993; Maloupa *et al.* 1999; Venezia *et al.*, 1997).

Nutrient availability is a major factor that influences the suitability of organic substrates for the plant growth (Caballero *et al.*, 2007; Verdonck,1992), which may depend on their elemental composition and other factors affecting dynamics and nutrient forms including the presence of dissolved organic compounds, biological stability of the growing medium, pH, and adsorption capacity (Caballero *et al.*, 2009; Van Labeke and Dambre, 1993). Optimum nitrogen and potassium uptake by the plant improve the quality and quantity of Gerbera. The appropriate amount of absorbed phosphorus improves roots growth and so better absorption of nutrients by the plant, improves the quality and quantity of flowers (Dufalt, 1991;

Pisanu, Carletti and Leoni, 1993; Khalaj, 2007), and the reduction of elements including phosphorus, potassium, magnesium, calcium etc. directly affect the rate of synthesis of certain other metabolites in plants (Sindhu *et al.*, 2010; Gull *et al.*, 2018). Appropriate range of concentrations of nitrogen, phosphorus, and potassium are 2.52-4.9, 0.25-0.7, and 3.1-5 percent, respectively and the appropriate range of trace elements as iron, manganese, zinc, copper, and boron in gerbera leaves on the order are 50-200, 40-250, 25-200, 6-50, and 20-60 mg kg^{-1} DW, respectively (Jeong, 2009; Hailu, 2018).
Keeping the above in mind, the present investigation was carried out to identify the appropriate soilless medium for increasing qualitative and qualitative traits of gerbera.

2. MATERIALS AND METHODS

This investigation was performed in Randomized Complete Block Design (RCBD) with 10 treatments and 3 replications over a period of 6 months for consecutive 2 years (Table 1a). Plants were fertilized with the same nutrient solution. In this investigation, 3-5, 1- 2, and 0.5-1 mm of expanded clay perlite, and sand were used respectively. The greenhouse temperature and relative humidity were 18-28 °C and 50-70%, respectively and also the amount of light was adjusted to 23000-25000 (Lumen/m^2). Then gerbera seedlings (Rosalin cultivar) were transplanted into 4-liter pots and irrigated three to four times every day. PH and electrical conductivity of water (nutrient solution) were 5.5-6.5 and 1.5-2 ds/m, respectively. During 6 months, some quantity and quality characteristics of flowers including vase life, stem neck diameter, stem diameter, flower diameter, stem height, flower number, as well as nutrient uptake by plant leaves were measured. Standard procedures were followed to collect data for growth and flowering parameters. The data were analyzed by using Duncan's Multiple Range (DMR) test at 1% and 5% probability level and were used to compare the differences between treatment means (Steel *et al.,* 1980).

3. RESULTS AND DISCUSSION

Morphological characteristics

The selection of media for growing gerbera was based on many factors including ease of use, cost, availability, water holding capacity, and profitability for producers. The results of the analysis of variance (Tables 2 and 3) showed that the 7th treatment, which included a mixture of perlite + peat + expanded clay (25% + 70% + 5%), produced maximum flower numbers (207 per square meter) compared to other treatments. Plants growing in sand bed produced only 76 flowers per square meter that had the lowest production among different media. The higher flower numbers of gerbera under perlite + peat + expanded clay (25% + 70% + 5%) could be the result of faster plant development, good root system and better physicochemical properties of mixes. The growth medium has a significant effect on the value of potted ornamental plants (Vendrame *et al.*, 2005). Cation exchange capacity (CEC) of Bed No.7 was 80 Cmol charge kg^{-1} (Table 1b). According to different researchers, organic materials and high cation exchange capacity (CEC) increase the absorption and storage of nutrients and water and also creates a suitable condition for plant root growth, all these can increase qualitative and quantitative characteristics of flowers. Salinity level and nutritional status have an important chemical role and also, water holding capacity and aeration are probably the most important physical factors in the development of a plant (Dewayne *et al.*, 2003). Nowak and Strojny reported that the total air capacity, shrinkage water capacity, bulk density, and porosity of the growing substrates have a crucial role in the weight and number of fresh flowers in gerbera (Nowak and Strojny, 2004). Table 2 shows that flower disc diameter was influenced by different media and the highest flower diameter (11.6 cm) was observed in the seventh treatment and the lowest flower diameter (10.9 cm) from sand alone (Table 3). Fakhri *et al.*, (1995) reported that using the mixes of perlite and peat led to the largest flower diameter. They have noted that physicochemical characteristics of media are important for better flower yield. Presence of organic matter was the main reason for differences between different Media (Fakhri, 1995). There was a significant difference in the flower height (Table 2), and the greatest flower height was produced in Medium 7 with 54.5 cm (Table 3). More yields and greater flower height produced by plants grown in medium 7 indicated that this is the best treatment for growing gerbera among these media. Medium 7, had the least salinity than other media (0.39 ds/m), so it was a good root medium, provided for growth and nutrient absorption of plants. Papadopoulos (1996) showed that an equal mixture of peat and perlite led to the production of the maximum flower height with 69 cm. Aswath and Pillai (2004) showed that electrical conductivity in the medium had a significant effect on flower diameter and also stalk thickness and length in gerbera. Ozcelik *et al.* (1996) observed a strong relationship between gerbera quantity and quality characteristics and physicochemical properties of the substrate.
In this experiment, a significant difference was observed in gerbera vase growth on media with different substrates (Table 2). In Medium 7, gerbera flowers had the longest vase life (13.6 days) (Table 3). The vase life is directly related to the size of flowers as well as dry matter production. This finding is in agreement with Manins *et al.* (1999) that showed significant differences in gerbera vase life between different substrates (Manins, 1999). De Jong (1978) showed that due to turgor pressure maintained, gerbera flowers with strong stem were less likely to fold in the vase. The flower set early produced high-quality cut flowers in coco peat combinations, as the vegetative growth was found to be better in this medium.

Nutrients uptake

The results showed that the amount of nitrogen uptake by plants in different substrates had a significant difference at 1% level of probability (Table 4). Comparison of the data showed that the plants growing in perlite + peat + expanded clay (25% + 70% + 5%) and sand alone had the highest and lowest N in the leaves (Table 5). Variance analysis of data showed that the effect of the substrates on the potassium of leaves had a significant difference at a 1% level of probability (Table 4). The data showed that the plants growing in perlite + peat (25% + 75%) and sand alone had the highest and lowest K in the leaves (Table 5). Sufficient nitrogen in the root environment will increase the shoot and root growth. Nitrogen increases photosynthesis by increasing the leaf thylakoids and stroma protein. Potassium has an important role in the production of proteins and hydrocarbons in plants. It provides the necessary pressure potential for growth by the production of high vacuole turgor in expanded cells. The optimum nitrogen and potassium uptake by the plant will improve the quality and quantity of plants like cut gerbera (Ozcelik, 1997; Marschner, 2012; Hagab *et al.*, 2018). The variance analysis showed that the effect of different substrates on leaf phosphorus was significant at 1% level of probability (Table 4). The data showed that the plants growing in perlite + peat + expanded clay (25% + 70% + 5%) and sand alone had the highest and lowest P in the leaves, respectively (Table 5). Phosphorus contributes energy transport in plant and thus is essential to the regulation of metabolic activities in the cytoplasm and chloroplasts, and so indirectly is effective on plant yield. The appropriate amount of phosphorus uptake produces more root growth and by a better nutrient absorption can improve the quality and quantity of plant (Pisanu, Leoni and Carletti 1994; Papadopaulos *et al.* 1996; Ozcelik, 1997). Variance analysis showed that the effect of media on the iron concentration of plant was significant at 1% level of probability (Table 4). Table of data showed that the plant growing in perlite + peat + expanded clay (25% + 70% + 5%) and sand alone had the maximum and minimum iron in the leaves, respectively (Table 5). Iron is essential in protein synthesis and the formation of chlorophyll in plants. Photosynthesis will be better by optimum iron uptake, so, plant growth and yield will be improved (Ozcelik, 1997; Marschner, 2012). The results of data analysis showed that the effect of media on manganese concentration was significant at 1% level of probability (Table 4). The data showed that plants in perlite + peat (25% + 75%) and sand alone had the highest and lowest amounts of manganese in the leaves, respectively (Table 5). Manganese is required for the decomposition reaction of water and oxygen in photosynthesis. The presence of Mn in the first electrons transport is necessary for the photosynthesis light reactions. It is necessary for light phosphorylation, and reduction of sulfate, nitrate, and carbon dioxide. Manganese deficiency not only reduces photosynthesis but also expands the disintegration of chloroplasts (Marschner, 2012). Data analysis showed that the effect of media on the Zinc concentration is significant at 1% level of probability (Table 4). Plants growing in perlite + peat + expanded clay (25% + 70% + 5%) and sand alone had the maximum and minimum values of the zinc uptake, respectively (Table 5). Zinc is carbonic anhydrase enzyme activator in cytoplasm and chloroplast, which converts carbon dioxide to bicarbonate reaction and vice versa and is necessary for sufficient supply of carbon dioxide for photosynthesis. It is also essential to make hormones as Indole acetic acid (IAA) from tryptophan that affects plants growth and development (Marschner, 2012). Analysis of variance showed that the effect of substrate on copper concentration in the plant was significant at 1% level of probability (Table 4). Plants growing in perlite + peat (25% + 75%) and sand alone as substrate had the highest and lowest leaf copper, respectively (Table 5). Copper plays an important role at electron transfer from photosystem 2 to 1, with activity regulation of plastocyanin and synthesis of quinone (Plastoquinone). Reduction in photosynthesis is due to the role of copper in chloroplast polypeptides activity. Copper deficiency reduces membrane fluidity and plastoquinone mobility that is required for electron transfer. In copper deficiency, not only delaying in flowering, and flower opening but also decreasing of the flower stalks number can be observed as well (Marschner, 2012).

Analysis of variance (Table 4) revealed that the effect of different media on boron concentration was significant at 5% probability. Comparison of the data showed that the plants growing in perlite + peat + expanded clay (25% + 70% + 5%) and sand alone as substrate had the maximum and minimum values of boron in the leaves, respectively (Table 5). Boron has an important role in root elongation, cell wall structure stability, protein metabolism, glucose and starch metabolism, flower formation, and seed production. A very quick response of the plant to the shortage of boron is reduced or stopped root elongation. Root elongation is resultant of various processes such as cell division and cell elongation. Boron deficiency will decrease the longitudinal growth of roots due to reducing the rate of cell division. Stability of the primary cell wall in plants is an important factor determining the size and shape of plant cells during development. Boron stabilizes the cell membrane by reacting with rich hydroxyl compounds. Membrane damage affects the transfer of metabolites and membrane-bound enzyme activity, required for plant growth and development (Marschner, 2012). The recent study confirmed that selecting the appropriate growing media for cut flower plants (in this case *gerbera jamesonii* L.) was very important from yield and quality points of view. The medium must ensure the production of plants with the required quality on a cost-effective basis. In the present study, perlite + peat + expanded clay mix (%25 + %70 + %5) led to the production of the maximum number of flowers per plant and quality characteristics were improved with this treatment. In conclusion, incorporation of perlite (25%) + peat (70%) + expanded clay (5%) caused the best physicochemical properties of plant growth, which enhanced nutrient availability to plants, in turn, improved the growth and quality. Therefore, it can be proposed as a media for gerbera planting.

4. CONCLUSIONS

There were significant differences among used substrates on yield and nutrient uptake of gerbera. The chemical analysis of substrate and plant leaves shows that there was increase in quantity and quality of cut gerbera as well as plant nutrient uptake (nitrogen, phosphorus and potassium and other micronutrient) in Media containing perlite (25%) + peat (70%) + expanded clay (5%). The results of this study can effectively be recommended for commercial production of cut gerbera in open hydroponic culture.

5. ACKNOWLEDGMENT

The authors wish to thank the Golirane Mehr nursery for their partial sponsorship to this study. We would also like to thank all the colleagues of the Ornamental Plants Research Center (OPRC) who participated in this project.

REFERENCES

1. Aswath, C., & Pillai, P. (2004). Effect of coco peat medium and electrical conductivity on production of

gerbera. *Journal of Ornamental Horticulture*, *7*(1), 15-22.

2. Bontemps F. 1999 - Gerbera: Study on soilless culture using coir. lien Hort, 21-24: 12-15.
3. Caballero, R., Ordovás, J., Pajuelo, P., Carmona, E., & Delgado, A. (2007). Iron chlorosis in gerber as related to properties of various types of compost used as growing media. *Communications in Soil Science and Plant Analysis*, *38*(17-18), 2357-2369.
4. Caballero, R., Pajuelo, P., Ordovás, J., Carmona, E., & Delgado, A. (2009). Evaluation and correction of nutrient availability to Gerbera jamesonii H. Bolus in various compost-based growing media. *Scientia Horticulturae*, *122*(2), 244-250.
5. De Jong, J. (1978). Dry storage and subsequent recovery of cut gerbera flowers as an aid in selection for longevity. *Scientia Horticulturae*, *9*(4), 389-397.
6. Dewayne, L. I., Richard, W. H., & Thomas, H. Y. (2003). Growth media for container grown ornamental plants. *The Environmental Horticulture Department, Florida Cooperative Extension Service, Institute of Food and Agricultural Sciences, University of Florida, BUL241*.
7. Dufault, R. J., Phillip, T. L., & Kelly, J. W. (1990). Nitrogen and potassium fertility and plant populations influence field production of gerbera. *HortScience*, *25*(12), 1599-1602.
8. Fakhri, M. N., Maloupa, E., & Gerasopoulos, D. (1993, October). Effects of substrate and frequency of irrigation on yield and quality of three Gerbera jamesonii cultivars. In *International Seminar on Soilless Culture Technology Protected Crops Mild Winter Climates 408* (pp. 41-46).
9. Gull, M. and Kausar, A., (2018). Comparative Analysis of Various Growth, Ions Uptake and other Physiological Performance of Two Rice (Oryza Sativa L.) Genotypes Under Altering Saline Conditions. *Pharmacophore, 9*(5), pp.73-81.
10. Hagab, R. H., Kotp, Y. H., & Eissa, D. (2018). Using nanotechnology for enhancing phosphorus fertilizer use efficiency of peanut bean grown in sandy soils. *Journal of Advanced Pharmacy Education & Research| Jul-Sep*, *8*(3).
11. Hailu, F. A., Wakjira, M., & Getahun, A. (2018). Fishpond Wastewater Versus Chemical Fertilizer On Tomato Productivity In Jimma, Oromia Region, Ethiopia. *World*, *7*(4), 82-89.
12. Jeong, K. Y., Whipker, B., McCall, I., & Frantz, J. (2008, August). Gerbera leaf tissue nutrient sufficiency ranges by chronological age. In *International Symposium on Soilless Culture and Hydroponics 843* (pp. 183-190).
13. Khalaj, M. (2007). Gerbera cultivation guide. National Research Station of Flowers and Ornamental Plants Publications. *Bulletin*, (86.394).
14. Khalaj, M. A., Kiani, S., Khoshgoftarmanesh, A. H., & Amoaghaie, R. (2017). Growth, quality, and physiological characteristics of gerbera (Gerbera jamesonii L.) cut flowers in response to different NO 3−: NH 4+ ratios. *Horticulture, Environment, and Biotechnology*, *58*(4), 313-323.
15. Malorgio, F., Magnani, G., Tognoni, F., & Casarotti, D. (1994). The gerbera cultivation on artificial media. First productive results. *Colture Protette*.
16. Maloupa E., Traka M. K., Papadopoulos A. 1999 - Wast water use to horticultural crops growing in soil and soilless media. *Acta Hort., 181*, 603-607.
17. Maloupa, E., Fakhri, M. N., Chartzoulakis, K., & Gerasopoulos, D. (1996). Effects of substrate and irrigation frequency on growth, gas exchange and yield of gerbera cv. Fame. *Advances in Horticultural Science*, 195-198.
18. Maloupa, E., Mitsios, I., Martinez, P. F., & Bladenopoulou, S. (1992, March). Study of substrates use in gerbera soilless culture grown in plastic greenhouses. In *Symposium on Soil and Soilless Media under Protected Cultivation in Mild Winter Climates 323* (pp. 139-144).
19. Manios, V. I., Papadimitriou, M. D., & Kefakis, M. D. (1993, October). Hydroponic culture of tomato and gerbera at different substrates. In *International Seminar on Soilless Culture Technology Protected Crops Mild Winter Climates 408* (pp. 11-16).
20. Marfà, O., Lemaire, F., Cáceres, R., Giuffrida, F., & Guérin, V. (2002). Relationships between growing media fertility, percolate composition and fertigation strategy in peat-substitute substrates used for growing ornamental shrubs. *Scientia Horticulturae*, *94*(3-4), 309-321.
21. Marschner, H. (2012). Marschner's mineral nutrition of higher plants. Vol. 89.
22. Mascecarini, L. (1998). Gerbera cultivation in growing media. *Hort. Inter. 6*(19): 86-88.
23. Mustapić-Karlić, J., Teklić, T., Parađiković, N., Vinković, T., Lisjak, M., & Špoljarević, M. (2012). The effects of light regime and substrate on flower productivity and leaf mineral composition in two gerbera cultivars. *Journal of plant nutrition*, *35*(11), 1671-1682.
24. Nowak, J. S., & Strojny, Z. (2004). Effect of physical properties of organic growing media on cut flower yield of gerbera. *Folia Universitatis Agriculturae Stetinensis. Agricultura (Poland)*.
25. Özçelik, A., Besroglu, A., Özaltin, A. S., & Özgümüs, A. (1997, November). The use of different growing media in greenhouse gerbera cut flower production. In *International Symposium Greenhouse Management for Better Yield & Quality in Mild Winter Climates 491* (pp. 425-432).
26. Papadopoulou, E., Gerasopoulos, D., & Maloupa, E. (1996). Effect of the substrate and frequency on irrigation on growth yield and quality of Gerbera Jamesonii Bolus cultivated in pots. *Agricoltura Mediterranea*, *126*, 297-302.
27. Pickering J. S. (1997). An alternative to peat. *The Garden, 122*, 428-429.
28. Pisanu B., Leoni S., Carletti M. (1994). Result of Gerbera cultivation on different inert substrates. *Informatore Agrario, 50*(37):69-72.
29. Pisanu, A. B., Carletti, M. G., & Leoni, S. (1993, April). Gerbera jamesonii cultivation with different inert substrates. In *International Symposium on New Cultivation Systems in Greenhouse 361* (pp. 590-602).

30. Ribeiro, H. M., Romero, A. M., Pereira, H., Borges, P., Cabral, F., & Vasconcelos, E. (2007). Evaluation of a compost obtained from forestry wastes and solid phase of pig slurry as a substrate for seedlings production. *Bioresource technology*, *98*(17), 3294-3297.
31. Roosta, H. R., Manzari Tavakkoli, M., & Hamidpour, M. (2016). Comparison of different soilless media for growing gerbera under alkalinity stress condition. *Journal of Plant Nutrition*, *39*(8), 1063-1073.
32. Sindhu, S. S., DB, G., Singh, M. C., & Dhiman, M. R. (2010). Effect of medium amendments on growth and flowering in gerbera. *Indian Journal of Horticulture*, *67*(4), 391-394.
33. Steel, R. G., & Torrie, J. H. (1980). *Principles and procedures of statistics, a biometrical approach* (No. Ed. 2). McGraw-Hill Kogakusha, Ltd..
34. Van Labeke, M. C., & Dambre, P. (1993, November). Gerbera cultivation on coir with recirculation of the nutrient solution: a comparison with rockwool culture. In *International Symposium on Water Quality & Quantity-Greenhouse 458* (pp. 357-362).
35. Vendrame, W. A., Maguire, I., & Moore, K. K. (2005). Growth of selected bedding plants as affected by different compost percentages. In *Proceedings of the Florida State Horticultural Society* (Vol. 118, pp. 368-371). Florida State Horticultural Society.
36. Venezia, A., Martignon, G., Schiavi, M., & Cassarotti, D. (1997). Soil-less culture of gerbera, open and closed systems. *Gerbera fuori suolo: sistema aperto e chiuso. Culture Protette*, *26*(9), 129-135.
37. Verdonck, O., & Gabriels, R. (1992). Reference method for the determination of physical properties of plant substrates. II. Reference method for the determination of chemical properties of plant substrates. *Acta Horticulturae*, *302*, 169-179.
38. Yau, P. Y., & Murphy, R. J. (1998, August). Biodegraded cocopeat as a horticultural substrate. In *XXV International Horticultural Congress, Part 7: Quality of Horticultural Products 517* (pp. 275-278).

Table 1a- Ratios of substrates used in this experiment

T_1	Fine sand
T_2	Peat + Fine Sand (25%+75%)
T_3	Peat + Fine Sand (50% +50%)
T_4	Perlite + Peat (75% + 25%)
T_5	Perlite + Peat (50% + 50%)
T_6	Perlite + Peat (25% + 75%)
T_7	Perlite + Peat + Expanded clay (25% + 70% + 5%)
T_8	Perlite + Peat + Expanded clay (50 %+ 25%+ 25%)
T_9	Perlite + Peat + Expanded clay (25%+ 50% + 25%)
T_{10}	Perlite + Expanded clay (50% + 50%),

Treatments mix by (v/v) of substrates

Table 1b- Physical and chemical properties of substrates used in this experiment

	substrates	Porosity (%)	CEC (CmolC/ kg)	EC (ds/m)	pH
1	Fine sand	40	0.75	1.04	6.91
2	Peat + Fine Sand (25%+75%)	41.1	3.5	1.02	6.87
3	Peat + Fine Sand (50% +50%)	42.7	7.7	0.99	6.82
4	Perlite + Peat (75% + 25%)	73.7	26.5	0.84	6.54
5	Perlite + Peat (50% + 50%)	79.4	57.2	0.65	6.15
6	Perlite + Peat (25% + 75%)	86.3	94.9	0.41	6.65
7	Perlite + Peat + Expanded clay (25% + 70% + 5%)	80.7	80.3	0.34	6.17
8	Perlite + Peat + Expanded clay (50 %+ 25%+ 25%)	62.7	22.4	0.49	7.75
9	Perlite + Peat + Expanded clay (25%+ 50% + 25%)	66.2	43.5	0.39	6.51
10	Perlite + Expanded clay (50% + 50%)	59	35.3	0.18	8.29

Table 2- Analysis of variance of Gerbera quality and quantity characteristics

Sources of Variation	df	Flower number	Flower diameter	Stem diameter	Stem neck diameter	Flower height	Vase life
Substrates	9	122.24 **	0.563 **	0.004 *	0.002 **	27.24**	2.46*
Error	20	21.37	0.078	0.001	0.001	7.22	0.769
CV%		21.47	2.47	5.39	3.74	5.4	7.78

ns, *, and ** indicate no significant difference, significant at 5%, and 1%, respectively

Table 3- Effect of different substrates on the yield and growth of gerbera

Treatment	Flower number (N/m^2)		Flower disc. Diameter (cm)		Stem diameter (cm)		Stem neck diameter (cm)		Flower height (cm)		Vase life (days)	
Fine sand	76	d	10.88	d	0.66	b	0.49	b	48.4	ac	10.6	b
Peat + Fine Sand (25%+75%)	78	d	11.63	b	0.69	b	0.52	ab	51.3	ac	11.4	b
Peat + Fine Sand (50% +50%)	114	bd	11.07	bc	0.66	b	0.52	b	50.4	ac	10.7	b
Perlite + Peat (75% + 25%)	158	ac	11.02	bc	0.65	b	0.49	b	44.9	c	11.6	b
Perlite + Peat (50% + 50%)	148	ad	11.13	bc	0.64	b	0.51	ab	51.6	ac	10.8	b
Perlite + Peat (25% + 75%)	156	ac	11.47	bc	0.67	b	0.50	ab	53.0	ab	10.3	b
Perlite + Peat + Expanded clay (25% + 70% + 5%)	207	a	12.35	a	0.79	a	0.58	a	54.5	a	13.6	a
Perlite + Peat + Expanded clay (50 %+ 25%+ 25%)	158	ac	11.02	bc	0.68	b	0.49	ab	48.4	ac	11.3	b
Perlite + Peat + Expanded clay (25%+ 50% + 25%)	184	ab	11.18	bc	0.68	b	0.51	ab	48.2	ac	11.1	b
Perlite + Expanded clay (50% + 50%),	158	ac	11.18	bc	0.69	b	0.51	ab	46.0	bc	11.3	b

Mean values followed by different letters at each column are statistically different (P = 0.05).

Table 4- Variance Analysis of nutrient uptake of gerbera

Sources of Variation	df	N	P	K	Fe	Mn	Zn	Cu	B
Substrates	9	1.930 **	0.066 **	0.751 **	27723.304 **	7060.853 **	1424.730 **	805.101 **	169.948 **
Error	20	0.068	0.003	0.161	133.140	66.730	44.12	69.08	8.92
CV%		6.53	9.02	10.29	2.54	6.11	5.29	11.25	7.98

ns, *, and ** indicate no significant difference, significant at 5%, and 1%, respectively

Table 5- Effect of different substrates on the nutrient uptake of gerbera

substrates	N %		P %		K %		Fe (mg kg^{-1})		Mn (mg kg^{-1})		Zn (mg kg^{-1})		Cu (mg kg^{-1})		B (mg kg^{-1})	
fine sand	1.27	f	0.36	e	2.76	b	63.06	f	62.00	d	75.66	d	25.25	d	25.66	e
peat + fine sand (25%+75%)	2.35	e	0.45	de	3.57	ab	69.90	ef	78.83	d	97.63	c	29.08	d	29.00	de
peat + fine sand (50 %+50%)	3.66	de	0.54	Cd	4.01	a	77.90	e	119.17	bc	121.66	b	42.00	ac	33.50	cd
perlite + peat (75% + 25%)	2.94	ce	0.71	ab	4.10	a	121.37	c	137.67	b	133.80	ab	35.75	bd	41.83	b
perlite + peat (50 %+ 50%)	3.37	bc	0.77	a	3.82	a	142.37	b	128.50	b	141.43	a	33.58	cd	38.83	bc
perlite + peat (%5% + 75%)	3.00	cd	0.74	ab	4.34	a	94.99	d	200.50	a	135.80	ab	48.25	a	33.83	cd
perlite + peat + expanded clay (25% + 70% + 5%)	4.17	a	0.80	a	4.63	a	155.73	a	194.83	a	148.56	a	44.92	ab	51.50	a
perlite + peat + expanded clay (50% + 25% + 25%)	3.40	bc	0.63	bc	3.73	b	121.09	c	103.33	bc	121.30	b	41.75	ac	37.50	bc
perlite + peat + expanded clay (25%+ 50% + 25%)	3.05	cd	0.73	ab	4.07	ab	137.51	b	192.67	a	123.20	b	26.23	d	38.00	bc
perlite + expanded clay (50% + 50%)	3.76	ab	0.71	ab	3.97	ab	103.90	d	120.33	bc	133.60	ab	42.67	ac	44.66	ab

Mean values followed by different letters at each column are statistically different (P = 0.05).