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Effect of Date Palm Wastes, Perlite and Magnesium on Growth and Flowering in Gerbera Plants (*Gerbera jamesonii* L.)

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ABSTRACT

This study evaluated the effects of date palm wastes + soil (1:1 v/v), perlite + soil (1:1 v/v), and soil with no additive, along with the spraying of $MgSO_4.7H_2O$ at (0, 50, and 100 mg L^{-1}) on the growth and flowering of potted gerbera. The results showed that adding date palm wastes to the soil significantly increased plant height (30.36 cm), number of leaves (6.91), branches (11.35) and suckers (3.39 per plant). Also, nitrogen, phosphorus and potassium contents in the leaves were recorded as 2.18%, 0.28%, and 2.34%, respectively. Leaf dry matter increased to 20.63%. Moreover, adding date palm wastes + soil increased chlorophyll, carbohydrates, and protein contents in the leaf to 1.76 mg g^{-1}. fresh wt., 14.14% and 13.64%, respectively. Flower stalk diameter reached 0.346 cm and the vase life increased to 12.26 days. The effect of magnesium increased plant height (27.75 cm), the number of suckers (3.05 per plant), and leaf area (136.3 cm^2) Likewise, there were increases in N (1.96%), P (0.25%), and K (2.03%), chlorophyll (1.45 mg g^{-1}. fresh wt.), carbohydrate (13.27%) and protein contents (12.28%). The flower stalk diameter became thicker (0.393 cm) when increasing the concentration of the Mg treatment. Also, the effect of Mg at 100 mg L^{-1} extended the vase life to 11.08 days. Some interactions between the media and magnesium treatments were significantly effective. The longest vase life (12.79 days) occurred in plants grown on date-palm wastes + soil, treated with 100 mg L^{-1} of Mg.

Introduction

Gerbera (*Gerbera jamesonii* L.) belongs to the Asteraceae family and is one of the most important, attractive, and well-known cut flowers. It is grown throughout the world and is ideal for use as a border plant, in pots, and for rock gardening. Above all, it is highly recommended for export. Gerbera is very fashionable because of its unique green features as an herb in decorative gardens and facets of interior design as a cut flower (Kanwar and Kumar, 2008; Metwally et al., 2015).

Parthasarathy and Nagaraju (1999) stated that gerbera is an herbaceous plant that blooms in different colors. Generally known as the African-American daisy which generates very attractive smells, its demand by consumers is noteworthy in the flower industry, especially as a cut flower and as a potted plant because of its beauty. Gerbera is one of the most exquisite flowers because of its unique size, shape, and attractive colors. It can also be used in rock gardens and pot culture. The

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flower stalks are long and leafless (Das and Singh, 1989).

Organic residues have been used as common soil additives that can improve the physical properties of the soil. Their mechanism of action usually occurs by supplying nutrients that affect the soil in positive ways. The regular use of organic residues can increase the level of organic matter in the soil, thereby improving the water-holding capacity, porosity, bulk density, and drainage (Koenig and Johnson, 1999).

Samiei et al. (2005) examined the impacts of date palm and peat moss wastes on several growth traits of *Aglaonema commutatum*. The results showed that the two substrates were similar in action and effect when analyzing several plant properties. Ghehsareh et al. (2011a) reported that date-palm peat is an appropriate media for soilless culture with suitable physical and chemical properties, availability, and low cost. Panj et al. (2012) indicated that different growth media had significant effects on most of the vegetative growth features and flowering characteristics. Adding regular amounts of organic manure improved the soil quality, whereas the loss of nutrients from the organic manure into the soil was partly attributed to the slow release of nutrients from the plant residues (Reddy and Mundinamani, 2014). Finally, excessive utilization of chemical fertilizers, especially when there are no organic amendments, can pollute the surrounding environment due to the excessive leaching of nutrients (Lim et al., 2015).

Magnesium is an essential macro-element for plant growth. Its deficiency can impair regular processes of photosynthesis in the leaves and could reduce photosynthetic efficiency (Skinner and Matthews, 1990). According to Mengel and Kirkby (2001), Mg is an important element of macronutrients with several physiological functions in plants. Also, the importance of Mg in plants is largely connected to photosynthesis. It is a central element of chlorophyll and it activates enzymatic processes. Mg also favorably influences assimilation.

Plants need Mg in relatively large quantities because this element comprises 2-20% of the dry weight of a plant. Its concentration increases in meristematic tissues (IPNI, 2007). Sahi (2005) indicated that spraying gerbera plants with 2 g L^{-1} magnesium led to an increase in the number of shoots, the number of leaves, and the leaf area, along with positive effects on flowering processes.

This research was conducted to evaluate the growth and flowering of Gerbera plants in response to the inclusion of date palm residues and perlite in the soil. This was hypothesized as an important strategy for soil amendments that can contribute to environmental sustainability. Growth was also examined in response to spraying magnesium onto the plants for the importance of magnesium in gerbera nutrition and because of the close association between magnesium and chlorophyll which is involved in the biosynthesis of assimilates in photosynthesis.

Material and Methods

The experiment was conducted at the Center of Date-Palm Research, University of Basrah (2018 and 2019). The aim was to examine the effects of three different growth media, i.e. date-palm wastes + soil (1:1 v/v), perlite (particle size in the range of 1 mm) + soil (1:1 v/v), and soil only (Table 1 and Table 2). Three concentrations of magnesium ($MgSO_4.7H_2O$) were applied (i.e., 0, 50, and 100 mg L^{-1}) on *G. jamesonii* plants.

Healthy 15-day-old seedlings of gerbera (cv. “Sweet smile”) were brought from a nursery in Baghdad and the three types of growth media were amended with date palm wastes. The wastes were gathered from the field and were chopped into small sizes and stored in plastic bags for controlling moisture and temperature. Four g kg-1 from each urea and superphosphate fertilizer were added to allow the start of fermentation. These bags were placed at warm temperatures (25 to 30 °C). Several openings were made on the bags for gaseous exchange. Every week, for one month, these materials were mixed and put into the bags again to assure a similar mix. Their moisture was monitored and constantly adjusted to 55%. Then, the bags were closed (Ghehsareh et al., 2011b). Four-liter plastic pots were filled with each of the three growing media, separately, as similar quantities of organic fertilizer were added to all pots. The seedlings were transplanted in the pots and were watered at field capacity limits as described by (Black, 1965). Two weeks after the transplanting process, magnesium solutions were prepared as described in the available literature (Anonymous, 2011). Then, the 30-day-old seedlings were sprayed with the said solutions, whereas distilled water was used for control plants. Spraying was repeated after another two weeks. Data were recorded when the first flower on the plant began to show color (Mateen et al., 2020) and included plant height, number of branches, number of suckers, number of leaves, and average leaf area. Eight mature leaves from each treatment (+ a piece of 1 cm2 paper) were dried in an electric oven at 22 °C, until the weight was constant and leaf area was calculated according to the following equation:

leaf area = G * S / g, as G = leaf weight, S = the area of the piece of paper and g = the paper's weight (Dvorinic, 1965). Also, dry matter in the leaves, as well as fresh and dry leaf weight were evaluated. Total chlorophyll content was estimated in the leaves according to Goodwin (1976). Carbohydrates in the leaves were estimated as described by Du Bois et al. (1956). Nitrogen content in the leaves was estimated according to Jackson (1958). Phosphorus and potassium were evaluated using a spectrophotometer (EMC LAB V-1100 Digital Spectrophotometer), while a flame photometer (FP8800) was used for the determination of potassium content (Page et al., 1982). Protein content in leaves was evaluated according to procedures of the A.O.A.C. (1970) by the following equation.

Protein = N % X 6.25.

Table 1. Chemicals and physical properties of the soil, perlite, and date palm wastes

Media	Properties	Values
Soil	pH	7.8
	Electric conductivity	2.42 ds m^{-1}
	Total Nitrogen	0.11 mg kg^{-1}
	Available Phosphorus	0.07 Cmol kg^{-1}
	Potassium	0.88 mg kg^{-1}
	Organic matter	22.97 g kg^{-1}
	Sand	848.70
	Silt	119.20
	Clay	32.10
	Texture	Loamy sand
Perlite	pH	7.6
	Electric conductivity	0.38
Date palm wastes	pH	6.5
	Electric conductivity	2.00 ds m^{-1}
	Total Nitrogen	2.57 %
	Available Phosphorus	0.23 %
	Potassium	1.29 %

Table 2. Typical chemical properties of perlite and the percentages of its constituents

Element composition %			Chemical composition %		
Silicon	Si	33.8	Silicon dioxide	SiO_2	72.08
Aluminum	Al	7.2	Alumina	Al_2O_3	12.92
Potassium	K	3.5	Titanium dioxide	TiO_2	0.90
Sodium	Na	3.4	Iron oxide	Fe_2O_3	1.50
Iron	Fe	0.6	Magnesium oxide	MgO	0.63
Calcium	Ca	0.6	Quick lime	CaO	0.88
Magnesium	Mg	0.2	Caustic soda	Na_2O	3.76
Mica	-	0.2	Potassium oxide	K_2O	4.33
Oxygen	O	47.5	Bound water	H_2O	3.0

(Samar and Saxena, 2016)

Several parameters of the flowers were recorded, including the number of days to first flowering, number of flowers, flower diameter (cm), flower stalk diameter (cm), and stalk length (cm). These were measured using a German Vernier Caliper (0.02 mm). After the flower fresh weight (g) was measured, the flowers were placed in an aerated oven at 70 ºC for 48 h until the weight reached a constant value. Vase life was measured on eight fully-opened flowers, taken randomly from each treatment, as they were collected early in the morning and placed in glass jars containing deionized water at room temperature (25±2 ºC). Vase life was determined by counting the number of days until senesced petals became unacceptable for exhibition (Iordachescu and Verlinden, 2005; Al-Abbasi et al., 2015).

The trial was a factorial experiment, adopted in a completely randomized block design (R.C.B.D.) with four replications (AL-Rawi and Khalaf-Alla, 2000). Mean values were compared via the least significant differences RLSD test (0.05). Statistical analysis was done by GenStat 7.2 (2007).

Results

Date palm wastes + soil (M1) had the most optimal effect on vegetative growth parameters (i.e. plant height, number of leaves, number of branches, and number of suckers), thereby having significant differences compared to the effects of other treatments (Table 3). The results also revealed that spraying magnesium solutions enhanced the values of plant height, number of suckers, and leaf area. This treatment was followed by M2 (perlite + soil), whereas minimum values were recorded in response to M3 (soil).

Some interactions significantly increased plant height, number of leaves, number of branches, number of suckers, and leaf area to reach maximum values (34.10 cm, 7.57 leaves per plant, 12.61 branches per plant, 3.84 suckers per plant and 165.9 cm^2 as leaf area, respectively). These values were maximum in plants grown on date palm wastes + soil and, also, in the soil-only media when treated with Mg3. Minimum values, however, were found in response to M3 (soil) when treated with Mg3. In effect, the plant height, the number of leaves, and the number of branches increased to 22.23 cm, 4.47, and 8.16, respectively. Meanwhile, the minimum average number of suckers (1.38) was recorded in plants grown on soil-only + Mg0 spray. The minimum leaf area (89.9 cm^2) was observed in plants grown on perlite + soil, and which received the Mg2 spray.

Table 3. Effect of date palm wastes + soil, perlite + soil, soil-only, and magnesium on some vegetative growth parameters of *Gerbera jamesonii*

Treatment			Plant height (cm)	No. of leaves per plant	No. of branches per plant	No. of suckers per plant	Leaf area (cm^2)
Date palm wastes + soil (M1)			30.36	6.91	11.35	3.39	125.2
Perlite + soil (M2)			26.19	5.46	10.52	2.64	123.8
soil only (M3)			23.83	4.99	9.87	1.94	126.7
L.S.D. ($P \leq 0.05$)			1.992	1.016	0.882	0.136	16.66
Mg concentration (mg L^{-1})		Mg0	25.65	5.73	11.15	2.29	109.6
		Mg1	26.97	5.76	10.31	2.62	129.7
		Mg2	27.75	5.87	10.28	3.05	136.3
L.S.D. ($P \leq 0.05$)			1.992	1.016	0.882	0.136	16.66
Growth Media X Mg con. (mg L^{-1})	M1	Mg0	26.19	6.03	10.74	2.95	97.8
		Mg1	30.79	7.12	10.70	3.38	111.8
		Mg2	34.10	7.57	12.61	3.84	165.9
	M2	Mg0	25.09	5.76	11.80	2.54	161.0
		Mg1	26.56	5.04	9.68	2.57	89.9
		Mg2	26.91	5.56	10.08	2.79	120.4
	M3	Mg0	25.68	5.40	10.91	1.38	129.9
		Mg1	23.57	5.10	10.54	1.92	127.5
		Mg2	22.23	4.47	8.16	2.51	122.6
L.S.D. ($P \leq 0.05$)			3.451	1.761	1.528	0.236	28.85

An analysis of variance revealed that the effect of growth media was significant on nitrogen, phosphorus, and potassium contents in Gerbera plant leaves, with the highest values of nitrogen, phosphorus, and potassium, i.e. 2.18, 0.28, and 2.34%, respectively, which were obtained in response to M1. Meanwhile, the lowest values (1.44, 0.18, and 1.36%, respectively) occurred in response to M3. Regarding the magnesium effect on N, P, and K contents, the three macro elements in leaf tissue increased significantly when the magnesium concentration was raised (Table 4).

Table 4. Effect of date palm wastes + soil, perlite + soil, soil-only, and magnesium on nitrogen, phosphorus, and potassium contents in the leaves of *Gerbera jamesonii*

Treatment		N%	P%	K%
Date palm wastes + soil (M1)		2.18	0.28	2.34
Perlite + soil (M2)		1.85	0.22	1.99
Soil (M3)		1.44	0.18	1.63
L.S.D. ($P \leq 0.05$)		0.062	0.009	0.079
Mg concentration (mg L^{-1})	Mg0	1.67	0.21	1.74
	Mg1	1.84	0.23	1.92
	Mg2	1.96	0.25	2.03
L.S.D. ($P \leq 0.05$)		0.062	0.009	0.079

Statistical analysis also showed that the interaction between the two factors significantly affected the absorption of these macro elements, since some treatment combinations resulted in far greater contents of nitrogen, phosphorus, and potassium, compared to the control. The maximum values of nitrogen, phosphorus, and potassium were 2.33, 0.32, and 2.42%, respectively, which were recorded in plants grown on date palm wastes + soil, and were sprayed with 100 mg L^{-1} magnesium. On the other hand, the minimum values of the three macro elements (1.25, 0.17, and 1.24%), respectively, were observed in plants that grew on soil-only medium and which were sprayed with distilled water (Fig. 1, Fig. 2, and Fig. 3).

Table 5 clearly shows variations in the chemical composition of gerbera leaves which occurred when adding date palm wastes and perlite. In particular, the chlorophyll content, carbohydrates, and protein contents were increased significantly in plants grown on M1, compared to the ones grown on M2. Spraying with magnesium at 50 or 100 mg L^{-1} significantly improved chlorophyll content, carbohydrates, and protein content in the leaves. Some treatment combinations had significant effects on these parameters too, so the maximum values of chlorophyll, carbohydrates, and protein contents were 1.89 mg g^{-1} fresh wt., 14.83%, and 14.58%, respectively, in plants grown on M1 that were sprayed with 100 mg L^{-1} magnesium.

Also, the growth of gerbera plants on date palm wastes + soil led to significant increases in the dry matter of leaves, whereas perlite + soil did not cause such a significant increase, even when combined with the magnesium treatment. On the other hand, the treatment combination of M1+Mg2 caused the most significant increase (21.27%) in leaf dry matter. As for the C/N ratio, the soil (M3) treatment yielded significant results. Some treatment combinations led to significant differences. For instance, the C/N ratio reached 8.80 in plants of the M3Mg0 treatment, resulting in the greatest value of C/N ratio.

From Table 6, it is evident that the M1 treatment (date palm wastes + soil) significantly increased the number of flowers per plant in comparison with the effect of M2 (perlite + soil) and M3 (soil-only). The effect of M2 was not significant on the results, even when spraying with Mg. On the other hand, the interaction between the two factors significantly affected the number of flowers, since the maximum value (11.96) occurred in response to M1+Mg1. In the case of flower diameter and stalk length, plants grown on M1 and M2 failed to show significant differences as compared to the soil-only treatment, and similar results were recorded in other Mg gradients. The highest significant values of flower diameter (12.06 cm) were found in plants grown on M1, sprayed with Mg2. Nonetheless, in the case of stalk length, the highest value (30.05 cm) was recorded in response to M2+Mg0.

Date palm wastes and perlite (M1 and M2) significantly enhanced the flower stalk diameter. In this regard, the effect of M1 significantly exceeded that of M2, and all magnesium treatments were found to be significant, as well as some treatment combinations. The M2Mg0 resulted in a flower-stalk diameter of 0.368 cm which was the highest value recorded. Regarding both fresh and dry weights of the flowers, the growth media and magnesium had insignificant effects. At the same time, some treatment combinations were significantly effective in increasing the fresh and dry weights of flowers. The M2Mg0 led to a fresh weight value of 11.73 g which was the highest, while the M1Mg2 caused the highest dry weight (4.327 g).

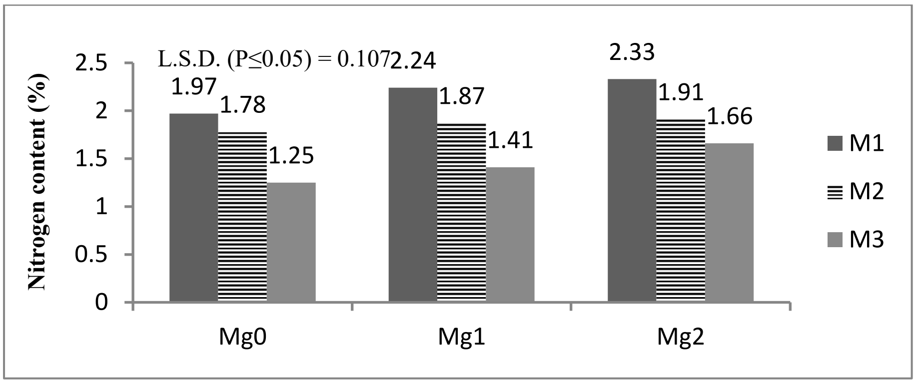

Fig. 1. Effect of treatment combinations among date palm wastes + soil, perlite + soil, soil-only, and magnesium on nitrogen content (%) in *Gerbera jamesonii* leaves. M1= date palm wastes + soil, M2 = perlite + soil, M3 = soil only Mg0, Mg1, and Mg2 = magnesium concentration

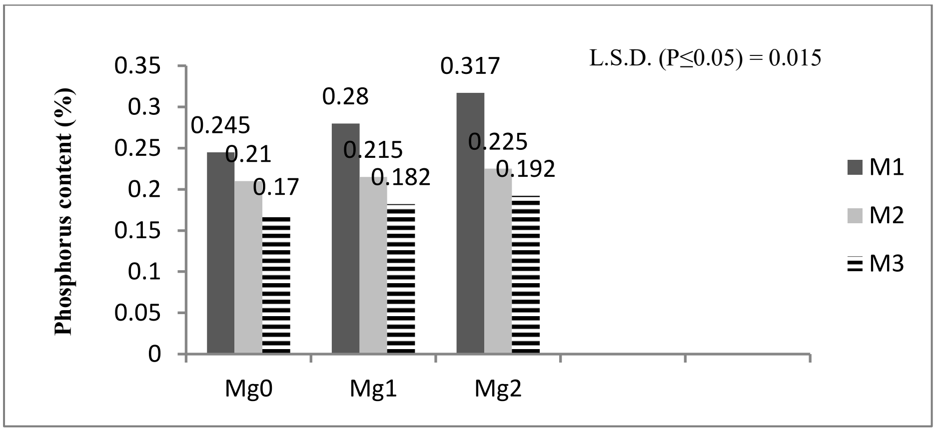

Fig. 2. Effect of treatment combinations of date palm wastes + soil, perlite + soil, soil-only, and magnesium on phosphorus content (%) in *Gerbera jamesonii* leaves. M1= date palm wastes + soil, M2= perlite + soil, M3 = soil only Mg0, Mg1, and Mg2 = magnesium concentration

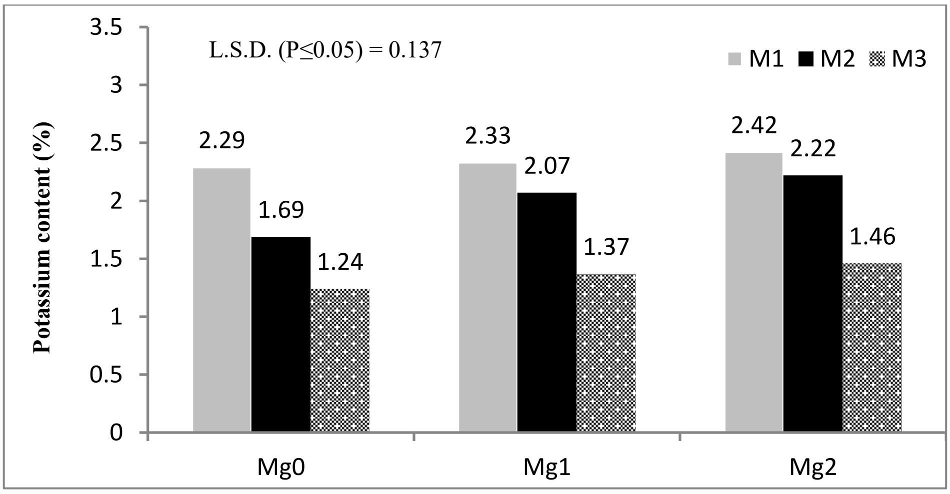

Fig. 3. Effect of treatment combinations of date palm wastes + soil, perlite + soil, soil-only, and magnesium on potassium content (%) in *Gerbera jamesonii* leaves.
M1 = date palm wastes + soil, M2 = perlite + soil, M3 = soil only
Mg0, Mg1, and Mg2 = magnesium concentration

Table 5. Effect of date palm wastes + soli, perlite + soil, soil-only, and magnesium on chemical compositions in leaf tissues of *Gerbera jamesonii*

Treatment			Chlorophyll Mg g^{-1}. fresh wt.	Dry matter %	Carbohy drates%	Protein %	C/N
Date palm wastes + soil (M1)			1.76	20.63	14.14	13.64	6.49
perlite + soil (M2)			1.43	16.10	12.78	11.56	6.91
soil (M3)			0.87	14.73	11.38	9.00	8.03
L.S.D. (P≤0.05)			0.046	2.793	0.222	0.384	0.398
Mg concentration (mg L^{-1})		Mg0	1.19	17.89	12.23	10.43	7.02
		Mg1	1.33	16.25	12.81	11.50	7.11
		Mg2	1.54	16.31	13.27	12.28	6.80
L.S.D. (P≤0.05)			0.046	2.793	0.222	0.384	0.398
Growth media X Mg concentration (mg L^{-1})	M1	Mg0	1.64	19.68	13.41	12.33	6.80
		Mg1	1.74	20.93	14.18	14.02	6.32
		Mg2	1.89	21.27	14.83	14.58	6.36
	M2	Mg0	1.25	19.95	12.38	11.13	6.96
		Mg1	1.44	14.45	12.89	11.66	6.91
		Mg2	1.60	13.89	13.08	11.91	6.87
	M3	Mg0	0.67	17.05	10.91	7.83	8.80
		Mg1	0.83	13.37	11.35	8.83	8.11
		Mg2	1.12	13.77	11.89	10.34	7.19
L.S.D. (P ≤0.05)			0.079	3.106	0.385	0.666	0.690

Table 6. Effects of date palm wastes + soil, perlite + soil, soil-only, and magnesium on some flowering parameters of *Gerbera jamesonii*

Treatment			No. of Flowers per Plant	Flower diameter (cm)	Stalk length (cm)	Stalk Diameter (cm)	Flower fresh wt. (g)	Flower dry wt. (g)
Date palm wastes + soil (M1)			11.18	11.11	23.86	0.346	10.04	3.388
perlite + soil (M2)			10.18	10.55	24.75	0.306	10.38	3.253
soil (M3)			9.32	10.43	21.25	0.262	9.79	3.014
L.S.D. (P≤0.05)			0.994	0.949	3.971	0.022	0.862	0.991
Mg concentration (mg L^{-1})		Mg0	10.46	11.10	25.22	0.338	10.65	2.600
		Mg1	10.43	10.27	22.68	0.383	9.49	2.759
		Mg2	9.80	10.72	21.96	0.393	10.07	3.297
L.S.D. (P ≤0.05)			0.994	0.949	3.971	0.022	0.862	0.991
Growth media X Mg concentration (mg L^{-1})	M 1	Mg0	10.34	10.21	21.08	0.325	9.97	3.237
		Mg1	11.96	11.07	23.67	0.355	9.83	2.600
		Mg2	11.25	12.06	26.84	0.358	10.33	4.327
	M 2	Mg0	10.66	11.55	30.05	0.368	11.73	3.803
		Mg1	9.77	9.11	22.45	0.280	9.45	2.890
		Mg2	10.12	11.01	21.74	0.270	9.97	3.067
	M 3	Mg0	10.36	11.56	24.53	0.323	10.25	3.760
		Mg1	9.55	10.62	21.91	0.243	9.19	2.787
		Mg2	8.03	9.10	17.32	0.220	9.92	2.495
L.S.D. (P≤0.05)			1.722	1.645	6.879	0.038	1.493	0.850

The effects of culture media and magnesium on the vase life of gerbera flowers are presented in Table 7. A significant increase was observed when plants were grown on date palm wastes + soil, which made the vase life 12.26 days. Also, the application of 100 mg. L^{-1} of Mg increased the vase life significantly to 11.08 days. Meanwhile, the longest vase life (12.79 days) was found in response to the effect of 100 mg. L^{-1} Mg on plants grown on date palm wastes + soil.

Table 7. Effects of date palm wastes + soil, perlite + soil, soil-only, and magnesium on the vase life (days) of gerbera flowers

Treatment		Vase life (day)
Date palm wastes + soil (M1)	Date palm wastes + soil (M1)	12.26
perlite + soil (M2)	perlite + soil (M2)	10.37
soil (M3)	soil (M3)	8.65
L.S.D. ($P \leq 0.05$) = 0.259		
Mg concentration (mg L^{-1})	Mg0	9.73
	Mg1	10.47
	Mg2	11.08
L.S.D. ($P \leq 0.05$) = 0.259		
Growth media X Mg concentration (mg L^{-1})	M1 Mg0	11.61
	Mg1	12.40
	Mg2	12.79
	M2 Mg0	9.50
	Mg1	10.42
	Mg2	11.19
	M3 Mg0	8.10
	Mg1	8.60
	Mg2	9.25
L.S.D. *($P \leq 0.05$)* = 0.450		

M1 = date palm wastes + soil, M2= perlite + soil, M3 = soil-only
Mg0, Mg1, and Mg2 = magnesium concentrations

Discussion

Like any other living organism, a plant needs to receive adequate quantities of requirements for its life cycle, e.g. water, nutrients, CO_2 and light. Although there are many variations in the types and amounts of these requirements among different organisms and plants, potted plants need adequate amounts of water. Pots have limited space to grow which should be considered when managing growth media. Using date palm wastes as soil amendment significantly improved the vegetative growth indicators (Table 3). The reason for these optimal performances in the vegetative growth of gerbera, as a result of adding date palm wastes, was probably the high organic matter content in organic wastes, which would have increased the water and nutrient holding capacity of the medium, and improved water utilization capacity of the plant. Also, adding plant wastes to the soil enhanced the activation of microorganisms, promoted the joining of soil particles, and then improved its structure which finally resulted in good plant growth. The effectiveness of this treatment was followed by that of M2 (perlite + soil), based on the ability of perlite to preserve moisture. Regarding the effectiveness of magnesium in improving the vegetative growth of gerbera, enzyme activation was facilitated and involved more CO_2 fixation in the Calvin cycle, thereby increasing the amount of assimilates for vegetative growth (Devlin and Witham, 1983). Similar results were reported by Abbass et al. (2013) in a study on *Ruscus* plants (*Ruscus sp.*).

The highest significant values recorded for nitrogen, phosphorus, and potassium contents in gerbera leaves (Table 4) when grown on date palm wastes + soil may be due to their higher availability in the media, in addition to the advances in phosphorus absorption. These results are in agreement with those in the available literature (Karama and Manwan, 1990). In the same table, the three macro elements increased significantly in the leaf tissue when a higher magnesium concentration was applied. This was related to the fact that the vital processes of nitrogen are affected by magnesium. For instance, it participates in the process of nitrate reduction in plants (Mengel and Kirkby, 2001)

As for the results presented in Fig. 1, Fig. 2, and Fig. 3, concerning the significant effects of the treatments on the absorption of the three macro elements (N, P, and K) by plants, their interference actions between the two factors caused far greater contents, compared to control plants. This can be explained by the significant increase in vegetative growth indicators (Table 3) which increased the absorption of these ions.

In Table 5, increases in the chlorophyll content, carbohydrates, and protein contents of gerbera leaves were observed by the effect of adding date palm wastes, which resulted from the high concentrations of nitrogen, phosphorus, and potassium contents in the plants (Table 4). When applying magnesium solutions, a significant increase occurred in chlorophyll content, carbohydrates, and protein content in the leaves. The increase was related to the role of magnesium in the synthesis of chlorophyll molecules. The role of this element is known to be in the activation of many enzymes associated with carbohydrate metabolism, including hexokinase, glucokinase, galactokinase, and fructokinase, along with the role of magnesium in proteins. Also, it acts as an activator of the enzymes involved in nucleic acids and works to stabilize ribosomes which are important for protein synthesis. Thus, its deficiency works to separate those ribosomes into smaller units (Mengel and Kirkby, 2001). The chemical composition in gerbera leaves was also characterized by some treatment combinations that had significant effects on some chemical indicators in gerbera. As a matter of fact, nutrient availability is one of the most important factors that can influence the suitability of organic substrates for plant growth and development (Caballero et al., 2007). These results are in agreement with those reported by Abdul-Sahib et al. (2021) as they found that chlorophyll content, total soluble carbohydrates, and protein contents increased significantly in the leaves of *Delphinium ajacis* when grown on date palm residues.

The enhancement in flowering growth and quality (Table 6, Fig. 1, and Fig. 2) were observed in plants grown on date palm wastes + soil, or perlite + soil. This observation resulted from the significant increase in vegetative growth (Table 3) when the numbers of leaves, branches, and suckers were higher. Also, flowering indicators were higher as a result of the carbohydrate content in the leaves (Table 5) which resulted in better flowering production than that in control plants. On the other hand, the plant height, number of suckers, and leaf area were significantly modified when spraying magnesium solutions at higher concentrations (Table 3). Similarly, the increase occurred when applying treatments that affected flowering indicators and vase life.

According to Sanwal et al. (2017), several suitable growth media are known to improve soil porosity and the activity of soil enzymes, e.g. acid phosphatase, dehydrogenase and protease, BAA, and CO_2 production. The said parameters are indices of enhanced biological activity in the soil, possibly due to the enrichment of soil organic matter. In this regard, Saad and El-Kholy (2000) stated that foliar application with magnesium sulfate increased the net assimilation rates, yield, and crude protein content of plants. This might be attributed to the improvement in the overall nutritional environment in the root zone, along with improvements in the physical, chemical, and biological properties of the soil (Masciandaro et al., 1997). These results are in agreement with those reported by Awang et al. (2009) in that suitable growth substrates are essential for flower quality and production, as they can affect the development and maintenance of plant root systems. Also, Verdonck and Gabriels (1992) reported that substrates can be suitable or unsuitable, depending on the nature and physiology of plants that are grown on them. High-quality substrates with proper physical and chemical properties can produce high yields and excellent plant quality. Correspondingly, selecting an optimal substrate among various materials is a vital step toward plant productivity (Olympios, 1992).

Conclusion

The addition of date palm wastes or perlite to the soil improved gerbera growth and flowering. A significant increase in some growth and flowering parameters took place when spraying the magnesium solution (100 mg L^{-1}). The longest vase life (12.79 days) occurred in plants grown on date-palm wastes + soil, along with the treatment of 100 mg L^{-1} of Mg.

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Conflict of interest

The authors indicate no conflict of interest for this work.

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