Impact of Duration Microwave Radiation Intensity and Growth Media on Morphological and Yield characteristics of (*Freesia hybrida*) plants production.

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Abstract

Microwave radiation effects depend on radiation frequency and exposure duration. Generally, low microwave exposure has been shown to positively affect the sprouting date of corms. Microwave irradiation can influence plant growth and development. The objective of this study is to examined the effects of different durations at (0, 5, 10, 15, and 20 seconds), different intensity (low and medium intensity) microwave radiation, and planted corms in different growth media (sand, peat moss, and a mixture of sand + peat moss) on the morphological and yield characteristics of *Freesia hybrida* plants. The results of the experiment emphasized the necessity of exposed Freesia corms to microwave radiation for 15 seconds, which demonstrated an accelerated sprouting date of 32.56 days, this treatment also increased plant height to 43.50 cm, and corms produced an average of 7.78 corms plant^{-1}, number of florets 7.33 florets spikes^{-1}, number of produced cormles to 35.89 cormels plant^{-1}. Additionally, Freesia plants exposed to microwave radiation for 10 seconds showed an increased vase life of cut flowers to 15.89 days. The effect of low-intensity microwave radiation resulted in an accelerated sprouting date of 34.42 days. Increasing the intensity of microwave radiation to medium improved plant height to 43.07 cm, the number of corms to 7.18 corms plant^{-1}, the number of florets per spike to 7.44 florets spike^{-1}, the vase life of cut flowers to 15.49 days, and the number of produced cormels to 34.69 cormels plant^{-1}. Furthermore, the growth medium affected the outcomes; planted corms in sandy soil resulted in an accelerated sprouting date of 33.80 days. Conversely, planted corms in peat moss increased the number of florets to 7.57 florets/spikes. Additionally, planted corms in a mixture of peat moss +sand produced an impressive plant height of 45.37 cm, number corms produced an average of 7.87 corms plant^{-1}, a vase life of cut flowers of 17.07 days, and produced number of cormles an average of 35.97 cormels plant^{-1}. These findings suggested that such practices could significantly enhance commercial Freesia production. Further research is recommended to explore the long-term impacts of these treatments and to optimize cultivation conditions for greater efficiency in Freesia farming.

Keywords: Microwave, intensity, Corm, Cormles, Sprouting, Freesia plant**.**

Introduction

Freesia is one of the most popular annuals bulb fragrant flowers of the Iridaceae family and Ixioideae subfamily **(Anderson, 2006 & Fu *et al.*, 2007)**. The genus Freesia contains about 11 species, all of which are native to South Africa specifically in West of Cape **(Manning *et al.*, 2010)**. *Freesia × hybrida* is a popular fragrant cut flower and flowering potted plant with long vase-life and wide color range, which make this flower a versatile floriculture crop **(Wang, 2007)**. Freesia is grown extensively in Europe and Japan as a cut-flower crop and also have potential to be cultivated as container-crop commodity **(Wulster & Gianfagna, 1991).** Its height ranges between 30-45 cm, and it is from the winter bulbs group under the climatic conditions of Iraq and the best temperature for its growth is between 13-20 °C **(AL-Khafaji & Chalabi, 2016)**. *Freesia hybrid* is the name of modern Freesia and plays a key role in cut Freesia production. The appealing shapes of Freesia and their wide range of color increase their versatility in commercial floriculture.

Physical treatment techniques are one of the safest popular methods for improving seed germination and plant growth. Physical elements have also been used to achieve a good biological change in plants without having an impact on the ecosystem **(Govindaraj *et al*., 2017)**. Electromagnetic waves, including as ultraviolet and microwave radiation, ultrasound, laser, and ionizing radiation, are among the physical elements now used for seed treatments. Microwave and UV radiation, in particular, are thought to be the most essential physical therapies for pre-sowing seed treatments **(Araujo *et al*., 2016)**. Microwaves (MWs) are a non-ionizing electromagnetic with a high-frequency range of 0.3 GHz to 300GHz and a wavelength range of 1m to 1mm **(Wang *et al*., 2018)**. Microwaves are a type of electromagnetic radiation with frequencies ranging from 300 MHz to 300 GHz. They work through absorption on a molecular level, resulting in vibration energy or heat, as well as biological impacts **(Pakhomov *et al*., 1998)**.

The effects of microwave radiation are dependent on the frequency and duration of exposure, and may be thermal or non-thermal effect. Low microwave exposure has been shown to have a good effect on seed germination; however, a protracted exposure reduces plant growth. Several authors recently observed that microwave has a good effect on barley seed germination at short microwave exposure times, but that longer exposure times had a negative effect on seed germination **(Abu-Elsaoud & Qari, 2017; Kretova *et al*., 2018)**. In addition, studies by **Amirnia (2014), Abu-Elsaoud (2015), Jakubowski (2015),** found that microwave can be utilized to promote seed germination in pepper, wheat, maize, bean, soybean, and lentil, respectively. **Moustafa et al., (2018)** investigated the influence of microwave irradiation with varying intensity and duration on corms Gladiolus plant, finding an all treatments showed significantly increased the studied growth parameters, i.e., plant height, number of leaves, length at the fourth leaf, leaf area at the fourth leaf, fresh and dry weight of leaves.

Planting media and nutritional requirements are one of the major factors that affect vegetative growth, flowering behavior and quality. Growing media play an important role in plant support, serve as a source of water and essential plant nutrients and permit the diffusion of oxygen to the roots. Growing media also provide a number of functions additions to support for the above ground part functions that often appear mutually exclusive. The materials of growing media consist of clay soil and sand as fully, or replaced it partially by one or more from various materials such as peat moss, leaf mould, farm yard manure, municipal sewage sludge, vermicompost etc., which led to alter the physico-chemical characteristics of the growing mixtures and affect plant growth, root system and nutritional status of the plant **(Habib, 2012; Atowa, 2012; & Mohamed, 2018).**

With studied the effects of growing media on vegetative growth, **Mazhar *et al*., (2010)** indicated that, sand + compost and sand + clay media for ornamental plants produced best vegetative growth in terms of plant height, leaf number/plant and leaves dry weight. In this respect, **Abd El Sattar *et al*., (2010)** reported that sand/compost medium for *Polianthes tuberosa* and *Hippeastrum vittatum* was the best for increasing most vegetative growth characteristics. As for the effect of growing media on flowering, **Badawy (1998)** reported that, Polianthes tuberosa plants grown in 1: 1: 1 loam/ sand/ peat (v/v) or 1: 1: 2 loam / sand/ peat (v/v) had generally taller spikes than those in other mixtures. In addition, the greatest number of flowers/spikes was obtained from plants grown in 1: 1: 1 loam/ sand/ vermiculite (v/v), whereas the lowest values were recorded on plants grown in 1: 2: 1 loam/ sand/ peat (v/v).

A few studies have demonstrated that microwave radiation has a positive effect in accelerating corm sprouting **(Chen *et al*., 2005)**. Therefore, the purpose of this study was to evaluate the effect of physical mutagens duration microwave radiation intensity, and growth media on morphological and yield characteristics on *Freesia hybrida* plants production.

Material and methods

This investigation was conducted in the research lab at Duhok Technical Institute, specifically in the greenhouse at the Bagera nursery, during a single growing season in 2024. Healthy Freesia corms, with a mean fresh weight of 15.9 grams and a diameter ranging from 3.7 to 4 cm, were imported from the Netherlands. These corms plant was exposed to different microwave radiation at (0, 5, 10, 15 and 20 seconds), intensity (low and medium), and corms plant were planted in three types of growth media (sand, peat moss, and sand + peat moss 1:1). The microwave unit used in this treatment was a Gosonic microwaveoven (GMO-330) with 50 Hertz, 230 Volt and 1400 Watt was utilized in the laboratory.

The experiment was designed using a Randomized Complete Block Design (RCBD) that included Three factors, with Three replicates. Each replicate consisted Thirty treatment each treatment contained Nine corms planted in pots size 22 cm^3 5*2*3*3*9= 810 corms, with a soil depth of 5 cm from the surface. As the plants grew, wire brackets were employed to support them and ensure steady growth.

The plants received fertilization with nano NPK fertilizers at a concentration of 1 $g.l^{-1}$. Essential maintenance operations, such as hoeing, weeding, and pest and disease control, were carried out as needed. The parameters investigated included sprouting date (days), plant height (cm), number of florets, vase life of cut flowers (days), and the number of corms and cormlets produced per plant. Data were analyzed using the SAS program, and mean comparisons were performed using Duncan's Multiple Range Test at a 5% significance level **(SAS, 2010)**.

Results

1-Sprouting Date (days) of Freesia

The results presented in **Table (1)** revealed that the sprouting date of Freesia plant corms was significantly influenced by different microwave radiation. Corms exposed to 15 seconds of microwave radiation demonstrated accelerated sprouting, required 32.56 days, compared with non-exposure microwave radiation that required 37.56 days. Whereas, the effect microwave intensity significantly influenced on accelerated sprouting, requiring 34.42 days for medium intensity, when compared with low intensity which reached 36.11 days. Additionally, the planted corms in growth media significantly impacted the sprouting date; when corms planted in sand sprouted more rapidly, required an average of 33.80 days compared to other growth media.

Table (1): Impact of Duration Microwave Radiation Intensity and Growth Media on Sprouting Date (days) of Freesia (*Freesia hybrida* L.) Plant.

Exposure Duration of microwave radiation	Microwave Intensity	Growth Media	Microwave Intensity *Duration microwave radiation	Effect Duration microwave radiation

		Sand	Peat moss	peat moss +sand		
0	0	41.00a	39.33a-c	39.00a-c	39.78a	37.56a
	0	38.00a-e	37.00a-f	31.00i	35.33b-d	
5 sec.	Low	31.00i	38.67a-d	39.00a-c	36.22bc	35.83b
	medium	31.67g-i	40.33ab	34.33d-i	35.44b-d	
10 sec.	Low	34.00e-i	36.00b-g	34.33d-i	34.78c-e	35.17b
	Medium	34.00e-i	36.67a-f	36.00b-g	35.56b-d	
15 sec.	Low	30.67i	34.00e-i	33.00f-i	32.56e	32.56c
	Medium	30.33i	31.00i	36.33b-f	32.56e	
20 sec.	Low	35.67c-h	38.00a-e	38.00a-e	37.22b	35.22b
	Medium	31.67g-i	31.33hi	36.67a-f	33.22de	
Duration microwave radiation * Growth Media	0	39.50a	38.17ab	35.00c-e	Effect Microwave Intensity	
	5 sec.	31.33fg	39.50a	36.67a-d		
	10sec.	34.00d-f	36.33b-d	35.17c-e		
	15 sec.	30.50g	32.50e-g	34.67c-e		
	20 sec	33.67d-f	34.67c-e	37.33a-c		
Microwave intensity * Growth Media	Low	34.47cd	37.20a	36.67ab	36.11a	
	Medium	33.13d	35.27bc	34.87cd	34.42b	
Effect Growth Media		33.80b	36.23a	35.77a		

Means with same letter for each factor and interactions are not significantly different at 5% level based on Duncan multiple Range Test.

The dual interaction between microwave intensity and duration revealed that the greatest number of days to corms sprouting 39.78 days occurred in control, while the least number of days 32.56 was observed for corms plants exposed to microwave radiation at duration 15-20 seconds and low and medium intensity. Conversely, the interaction between microwave intensity and growth media significantly affected the sprouting date, with the highest number of days to corms sprouting 37.20 days recorded for plants exposed to low intensity microwave radiation and interacted with peat moss growth media. In comparison, the least average days to sprouting 33.13 days were noted for plants exposed to medium microwave radiation and sand media. Additionally, the interaction between duration of microwave radiation and growth media showed that significant differences in days sprouting characteristics. The earliest sprouting corm at 30.50 days was recorded for plants exposure to microwave radiation at 15 second with sand media, while the longest duration for corms sprouting 39.50 days was observed for plants not exposed to microwave radiation and grown corms in sand media.

The triple interaction among the studied factors significantly influenced the accelerated sprouting date of Freesia corms. Plants exposed to medium intensity for 15 seconds and sand media required the least number of days to sprouting 30.33 days, whereas the corms plants not exposed to microwave radiation with a combination of sand needed the maximum of days to corms sprout to reached to 41.00 days.

2- Plants height (cm)

The results in **Table (2)** indicated that exposure of corms Freesia plants to microwave radiation for a duration 15 seconds resulted in a significantly increased plant height reached to 43.50 cm, respectively compared to the 10 second which reached to 40.22 cm. Additionally, increasing the microwave intensity from low to medium significantly enhanced the plants height, raised from 40.62 to 43.07 cm. Furthermore, corms planted in a media composed of peat moss + sand also caused significantly increased plant height which reached to 45.37 cm, respectively compared to 39.60 cm for corms planted in pure sand.

The interaction between microwave intensity and exposure duration caused a significantly affected the plant height. The highest plant height reached to 44.56 cm was observed for corms plants exposed to medium microwave intensity at 20 second when compared to 37.33 cm for plant exposed to low microwave intensity at 10 second. The interaction between microwave intensity and growth media significantly affected the plant height. The highest plant height reached to 46.53 cm was observed for plants exposed to medium microwave intensity interacted with peat moss when compared to 37.13 cm, for plant exposed to low microwave intensity and interacted with sand growth media. Additionally, the interaction between exposure to duration of microwave radiation and growth media demonstrated that corms plants exposure to microwave radiation at 20 second interacted with peat moss + sand caused significantly increase plant height which reached to 48.67 cm, when compared with least value which reached to 37.50 cm for corms plant not exposure microwave radiation and growth corms in sand media.

The triple interactions among the exposure duration of microwave intensity, and growth media factors. Indicated that corm plants exposed to medium microwave intensity for 10 seconds, and peat moss + sand mixture, significantly increased plant height which reached to 49.67 cm, compared with least value to 35.00 cm for the corms plant exposed to low microwave intensity at 5 second in sand growth media.

Table (2): Impact of Duration Microwave Radiation Intensity and Growth Media on Plants height (cm) of Freesia (Freesia hybrida L.) Plant.

Exposure Duration of microwave radiation	Microwave Intensity	Growth Media			Microwave Intensity *Duration microwave radiation	Effect Duration microwave radiation
		Sand	Peat moss	peat moss + sand		
0	**0**	36.33d-f	42.00a-f	41.67a-f	40.00ab	40.33b
	0	38.67d-f	39.33d-f	44.00a-d	40.67ab	
5 sec.	**Low**	37.33d-f	44.00a-d	41.00b-f	40.78ab	42.28ab
	Medium	42.00a-f	39.67c-f	49.67a	43.78a	
10 sec.	**Low**	35.00f	35.33e-f	41.67a-f	37.33b	40.22b
	Medium	43.00a-f	43.67a-b	42.67a-f	43.11a	
15 sec.	**Low**	39.00d-f	44.67a-d	47.67a-c	43.78a	43.50a
	Medium	43.33a-e	38.33d-f	48.00ab	43.22a	
20 sec.	**Low**	38.00d-f	36.67d-f	49.00ab	41.22ab	42.89ab
	Medium	43.33a-e	42.00a-f	48.33ab	44.56a	
Duration microwave radiation * Growth Media	**0 sec**	37.50d	40.67cd	42.83b-d	**Effect Microwave Intensity**	
	5 sec	39.67d	41.83cd	45.33a-c		
	10 sec	39.00d	39.50d	42.17cd		
	15 sec	41.17cd	41.50cd	47.83ab		
	20 sec	40.67cd	39.33d	48.67a		
Microwave intensity *Growth Media	**Low**	37.13d	40.53c	44.20ab	40.62b	
	Medium	42.07bc	40.60c	46.53a	43.07a	
Effect Growth Media		39.60b	40.57b	45.37a		

Means with same letter for each factor and interactions are not significantly different at 5% level based on Duncan Multiple Range Test.

3- Corms number/plant^{-1}

The results in **Table (3)** indicated that exposure of corm plants to microwave radiation for a duration of 15 seconds resulted in a significant increase in the number of corms, reached an average of 7.78 corms plant^{-1}, compared to least value reached to 5.78 corms plant^{-1} for plant exposed to microwave radiation at 20 second. Additionally, increased the microwave intensity from low to medium significantly enhanced the number of corms, raised from 6.27 to 7.18 corms plant^{-1}. Furthermore, corms planted in a media composed of peat moss + sand also caused significantly effected on this characteristic which reached to 7.87 corms plant^{-1}, respectively compared to 5.60 corms plant^{-1} for the planted corms in sand.

The interaction between exposure duration and microwave intensity caused a significantly affected the number of corms produced. The highest corm count, reached to 8.33 corms plant^{-1}, was observed for plants exposed to medium microwave intensity for 15 seconds. Conversely, the lowest count was 5.11 corms plant^{-1} for the for corms plant to low microwave intensity for 20 seconds. Furthermore, the interaction between microwave intensity and growth media revealed that plants exposed to medium microwave intensity and interacted with peat moss + sand produced the highest significant corms counted of 8.33 corms plant^{-1}. In comparison, plants exposed to low microwave intensity interacted with sand media lower count of 4.67 corms plant^{-1}. Additionally,

Table (3): Impact of Duration Microwave Radiation Intensity and Growth Media on Corms number/plant of Freesia (Freesia hybrida L.) Plant.

Exposure Duration of microwave radiation	Microwave Intensity	Growth Media			Microwave Intensity *Duration microwave radiation	Effect Duration microwave radiation
		Sand	Peat moss	peat moss + sand		
0	0	5.33e-h	6.00c-h	7.00a-g	6.11bc	6.61bc
	0	7.67a-f	5.00f-h	8.67a-c	7.11ab	
5 sec.	Low	4.33gh	6.67b-g	7.00a-g	6.00bc	6.28bc
	Medium	6.33b-h	5.67d-h	7.67a-f	6.56ab	
10 sec.	Low	4.33gh	8.33a-d	8.00a-e	6.89ab	7.17ab
	Medium	8.67a-c	6.00c-h	7.67a-f	7.44ab	
15 sec.	Low	5.00f-h	9.00ab	7.67a-f	7.22ab	7.78a
	Medium	6.67b-g	8.67a-c	9.67a	8.33a	
20 sec.	Low	4.33gh	3.67h	7.33a-f	5.11c	5.78c
	Medium	3.33h	8.00a-e	8.00a-e	6.44bc	
Duration *Growth Media	0	6.50b-e	5.50d-f	7.83ab	Effect Microwave Intensity	
	5 sec.	5.33e-f	6.17b-e	7.33a-d		
	10 sec.	6.50b-e	7.17a-e	7.83ab		
	15 sec.	5.83c-e	8.83a	8.67a		
	20 sec	3.83f	5.83c-e	7.67a-c		
Microwave intensity *Growth Media	Low	4.67c	6.73b	7.40ab	6.27b	
	Medium	6.53b	6.67b	8.33a	7.18a	
Effect Growth Media		5.60c	6.70b	7.87a		

Means with same letter for each factor and interactions are not significantly different at 5% level based on Duncan Multiple Range Test.

the interaction between exposure duration microwave and growth media demonstrated a significant effect, with the highest corm count of 8.83 corms plant^{-1} noted in plants exposed microwave for 15 seconds interacted with peat moss growth media. In contrast, the lowest corms counted of 3.83 corms plant^{-1} occurred in plants exposed microwave for 20 seconds and interacted with sand growth medium.

The triple interactions among exposure duration of microwave intensity, and growth media factors indicated that plants exposed to medium microwave intensity for 15 seconds, and planting in peat moss + sand mixture, produced the highest number of corms, reached to 9.67 corms plant^{-1}. In contrast, the lowest value recorded was 3.33 corms plant^{-1} for those plant exposed to the medium microwave intensity at duration 20 second and corms grown in sand media.

4- Number of florets /spikes

The results in **Table (4)** indicated that exposure of corms Freesia plants to microwave radiation for any duration did not have any significant increase in the number of florets, Additionally, increasing the microwave intensity from low to medium caused significantly increased the number of florets, raised from 6.56 to 7.44 florets /spikes. Furthermore, corms planted in a media composed of peat moss also significantly increased these characters, reached 7.59 florets /spikes, respectively compared to 5.93 florets /spikes for the plants grown in sand.

The interaction between exposure duration of microwave intensity significantly affected the number of florets produced. The highest number of florets reached to 8.00 florets /spikes, was observed for plants exposed to medium microwave intensity for 5 seconds. Conversely, the lowest counted was 5.78 florets /spikes was observed for plants exposed to low microwave intensity for 20 seconds. Furthermore, the interaction between microwave intensity and growth media revealed that plants exposed to low microwave intensity and interacted with peat moss and sand + peat moss produced the highest significant number of florets of 7.60 florets /spikes. In comparison, plants exposed to low microwave intensity with sand medium growth yielded a lower count of 4.67 florets /spikes. Additionally, the interaction between exposure duration microwave radiation and growth media demonstrated a significant effect, with the number of florets count of 8.83 florets /spikes noted in plants exposed for 15 seconds grown in peat moss, when compared with the lowest number of florets of 5.17 florets /spikes occurred in plants not exposed microwave radiation, and grown corms in sand medium.

The triple interactions among exposure duration, microwave intensity, and growth media factors indicated that corm plants exposed to medium microwave intensity for 5 seconds, and peat moss medium, produced the highest number of florets, reached an average of 9.00 florets /spikes. In contrast, the lowest value recorded was 4.33 florets /spikes for the corms plant exposed to low microwave intensity at 5-10-20 second and grown corms in sand medium

Table (4): Impact of Duration Microwave Radiation Intensity and Growth Media on Number of florets /spikes of Freesia (Freesia hybrida L.) Plant.

Exposure Duration of microwave radiation	Microwave Intensity	Growth Media			Microwave Intensity *Duration microwave radiation	Effect Duration microwave radiation
		Sand	Peat moss	peat moss + sand		
0	Low	5.33d-f	7.33a-e	7.00a-e	6.56bc	6.78a
	Medium	5.00ef	7.33a-e	8.67a	7.00a-c	
5 sec.	Low	4.33f	7.67a-d	7.00a-e	6.33bc	7.17a
	Medium	7.33a-e	9.00a	7.67a-d	8.00a	
10 sec.	Low	4.33f	8.33ab	8.00a-c	6.89a-c	7.17a
	Medium	8.67a	6.00b-f	7.67a-d	7.44ab	
15 sec.	Low	5.00ef	9.00a	7.67a-d	7.22ab	7.33a
	Medium	7.67a-d	8.67a	6.00b-f	7.44ab	
20 sec.	Low	4.33f	5.67c-f	7.33a-e	5.78c	6.56a
	Medium	7.33a-e	6.67a-f	8.00a-c	7.33ab	
Duration microwave radiation *Growth Media	0	5.17e	7.33a-d	7.83a-c	Effect Microwave Intensity	
	5 sec.	5.83de	8.33ab	7.33a-d		
	10 sec.	6.50c-e	7.17a-d	7.83a-c		
	15 sec.	6.33c-e	8.83a	6.83b-d		
	20 sec	5.83de	6.17c-e	7.67a-c		
Microwave intensity *Growth Media	Low	4.67b	7.60a	7.40a	6.56b	
	Medium	7.20a	7.53a	7.60a	7.44a	
Effect Growth Media		5.93b	7.57a	7.50a		

Means with same letter for each factor and interactions are not significantly different at 5% level based on Duncan Multiple Range Test.

5- Vase life (days)

The results in **Table (5)** demonstrated that exposure of corms Freesia plant to microwave radiation for 10 seconds resulted in a significantly increased the Vase life cut flower, which reached to 15.89 days respectively compared to the least value which reached 13.56 days for the plant exposed to microwave radiation at 20 second. Additionally, increasing the microwave intensity from low to medium caused a significantly enhanced the Vase life cut flower, raised from 13.69 to 15.49 days. Furthermore, Freesia corms planted in a media composed of peat moss + sand significantly increase vase life cut flower reached to 17.10 days, when compared to 13.20 days for those planted in sand.

Table (5): Impact of Duration Microwave Radiation Intensity and Growth Media on vase life (days) of Freesia (Freesia hybrida L.) Plant.

Exposure Duration of microwave radiation	Microwave Intensity	Growth Media			Microwave Intensity *Duration microwave radiation	Effect Duration microwave radiation
		Sand	Peat moss	peat moss + sand		
0	0	11.67c-e	11.00de	17.00a-c	13.22c	15.06ab
	0	19.00a	15.00a-e	16.67a-d	16.89a	
5 sec.	Low	11.67c-e	12.67b-e	17.33a-c	13.89a-c	14.67ab
	Medium	16.33a-d	14.00a-e	16.00a-d	15.44a-c	
10 sec.	Low	12.33c-e	15.33a-e	18.33ab	15.33a-c	15.89a
	Medium	15.33a-e	15.33a-e	18.67a	16.44ab	
15 sec.	Low	11.00de	12.00c-e	17.00a-c	13.33bc	13.78b
	Medium	11.67c-e	16.00a-d	15.00a-e	14.22a-c	
20 sec.	Low	12.00c-e	10.00e	16.00a-d	12.67c	13.56b
	Medium	11.00de	13.33a-e	19.00a	14.44a-c	
Duration microwave radiation *Growth Media	0	15.33a-d	13.00c-e	16.83a-c	Effect Microwave Intensity	
	5 sec.	14.00b-e	13.33c-e	16.67a-c		
	10 sec.	13.83b-e	15.33a-d	18.50a		
	15 sec.	11.33e	14.00b-e	16.00a-c		
	20 sec.	11.50de	11.67de	17.50ab		
Microwave intensity *Growth Media	Low	11.73c	12.20c	17.13a	13.69b	
	Medium	14.67b	14.73b	17.07a	15.49a	
Effect Growth Media		13.20b	13.47b	17.10a		

Means with same letter for each factor and interactions are not significantly different at 5% level based on Duncan Multiple Range Test.

The interaction between duration and intensity of microwave radiation significantly affected the vase life cut flower. The highest vase life, reached 16.89 days, was observed for plants not exposed to microwave radiation respectively compared with the lowest was 12.67 days for the plants exposed to low microwave intensity for 20 seconds. Furthermore, the interaction between microwave intensity and growth media revealed that plants exposed to low microwave intensity in interacted with peat moss + sand produced the highest significant effected on vase life cut flower which reached to 17.13 days, respectively compared with plants exposed to low microwave intensity and corms grown in sand which reached 11.73 days. Additionally, the interaction between exposure duration to microwave and growth media demonstrated a significant effect, with the highest vase life cut flower of 18.50 days noted in plants exposed microwave radiation for 10 seconds grown in peat moss + sand, respectively compared with the lowest vase life of 11.33 days occurred in plants exposed for 15 seconds and grown in sand media.

The triple interactions among exposure duration, microwave intensity, and growth media factors indicated that plants not exposed microwave radiation and grown in sand medium, also the medium microwave intensity for 20 seconds, and grown in peat moss + sand, significantly increase vase life cut flower which reached to 19.00 days, respectively compared with the lowest value recorded was 10.00 days for those plant exposed to the low microwave intensity for 20 second and grown in peat moss medium.

6- Number of produces Cormles (Cormles plant^{-1})

The results in **Table (6)** indicated that exposure of Freesia corm plants to microwave radiation for a duration of 15 seconds resulted in a significant increase in the number of produces Cormles, reaching an average of 35.89 Cormles plant^{-1}, respectively compared to the least value which reached 30.44 Cormles plant^{-1} for plant not exposure to microwave radiation. Additionally, increasing the microwave intensity from low to medium significantly enhanced the number of produces Cormles rasied from 32.02 to 34.69 Cormles plant^{-1}. Furthermore, corms planted in a media composed of peat moss +s and significantly increase number of produces Cormles reached to 35.97 Cormles plant-^{1,} compared to 29.73 Cormles plant^{-1}for those planted grown in sand medium.

The interaction between exposure duration and microwave intensity significantly affected on the number of produces Cormles. The highest Number of produces Cormles plant, reached 36.89 Cormles plant^{-1}, was observed for plants exposed to medium microwave radiation for 5 seconds. Respectivly compared with the lowest value was 25.67 Cormles plant^{-1} for the plants not exposed to microwave radiation. Furthermore, the interaction between microwave intensity and growth media revealed that plants exposed to medium microwave intensity interacted with peat moss produced the highest significant number of produces Cormles plant of 36.87 Cormles plant^{-1}, in comparison, plants exposed to low microwave intensity with sand media a lower number of produces Cormles plant of 28.20 Cormles plant^{-1}. Additionally, the interaction between duration exposure duration microwave radiation and growth media demonstrated a significant effect, with the highest 41.00 Cormles plant^{-1} noted in plants not exposed for 5 seconds and grown in peat moss + sand, in contrast, the lowest Number of produces Cormles of 23.50 Cormles plant^{-1} occurred in plants not exposed microwave radiation and grown in sand medium.

The triple interactions among exposure duration, microwave intensity, and growth media factors indicated that plants exposed to medium microwave intensity for 5 s seconds, and using a sand + peat moss, significantly increase number of produces Cormles which reached to 42.00 Cormles plant^{-1}, respectively compared with the lowest value recorded was 20.33 Cormles plant-^{1}for plant not exposed to microwave radiation but grown in sand medium.

Table (6): Impact of Duration Microwave Radiation Intensity and Growth Media on Number of produces Cormles plant^{-1} of Freesia (Freesia hybrida L.) Plant.

Exposure Duration of microwave radiation	Microwave Intensity	Growth Media			Microwave Intensity *Duration microwave radiation	Effect Duration microwave radiation
		Sand	Peat moss	peat moss + sand		
0 sec.	0	20.33i	24.00hi	32.67e-g	25.67c	30.44b
	0	26.67gh	38.00a-e	41.00ab	35.22ab	
5 sec.	Low	28.67f-h	33.00d-f	40.00a-c	33.89ab	35.39a
	Medium	32.67e-g	36.00a-e	42.00a	36.89a	
10 sc.	Low	26.00hi	33.67c-f	37.67a-e	32.44b	32.56b
	Medium	35.00b-f	37.00a-e	26.00hi	32.67b	
15 sec.	Low	39.67a-d	33.33c-f	34.67b-f	35.89ab	35.89a
	Medium	33.33c-f	37.67a-e	36.67a-e	35.89ab	
20 sec.	Low	26.33hi	35.33b-e	35.00b-f	32.22b	32.50b
	Medium	28.67f-h	35.67a-e	34.00c-f	32.78b	
Duration microwave radiation *Growth Media	0	23.50g	31.00d-f	36.83b	Effect Microwave Intensity	
	5 sec.	30.67e-f	34.50b-e	41.00a		
	10 sec.	30.50e-f	35.33b-d	31.83c-f		
	15 sec.	36.50b	35.50bc	35.67bc		
	20 sec.	27.50f	35.50bc	34.50b-e		
Microwave intensity *Growth Media	Low	28.20c	31.87b	36.00a	32.02b	
	Medium	31.27b	36.87a	35.93a	34.69a	
Effect Growth Media		29.73b	34.37a	35.97a		

Means with same letter for each factor and interactions are not significantly different at 5% level based on Duncan multiple Range Test.

Discussions

The exposed corms of the Freesia plant subjected to microwave radiation for 15 seconds resulted in a significant acceleration of sprouting days, an increase in plant height, a higher number of corms, and greater cormles production per plant compared to other treatments, as illustrated in Tables 1, 2, 3 and 6. Conversely, reduction the exposure duration to 10 seconds significantly enhanced the vase life of cut flower, as shown in Table 5. Moreover, exposed the corms of the

Freesia plant to varying intensities of microwave radiation had positive effects on all treatments. Specifically, low-intensity microwave radiation resulted in a significant acceleration in the number of sprouting days, as illustrated in Table 1. Meanwhile, medium-intensity microwave radiation significantly increased plant height, the number of corms per plant, the number of florets per spike, the vase life of the plant, and the production of cormels per plant, as detailed in Tables 2, 3, 4, 5, and 6. This result may be due to the optimal duration and intensity Microwave radiations accelerate Freesia growth by enhancing cellular activity, nucleic acid synthesis, enzyme activation and hormone regulation. This stimulates sprouting, increases plant height, boosts corm production and enhances cormels formation **(Singh *et al*., 2019; Taiz & Zeiger, 2010; & Sharma *et al*., 2020).** This early sprouting and increase another character of Freesia corms, these results may be due to duration to microwave intensity radiation was probably related with the increase in the activities of gibberellins and auxins and disappearance of inhibitors. **Karki & Srivastava (2010)**. These results are agreed with **(Kuldeep *et al*., 2017 & Sudha, 2016)**, on (Gladiolus hybridus). and **Patel *et al*., (2018)** on Gladiolus. who found that the increase in sprouting percentage % and stimulating number of days required sprouting may be due to physical treatments action on enhancing the hydrolysis of the complex compounds (carbohydrate, fats, proteins) in corms to simple compounds (sugar, fatty acid, amino acid) this could happen directly or indirectly by affecting the enzymatic reactions in corms. However, Microwaves are nonionizing radiations which are the part of the electromagnetic spectrum. **(Ragha *et al*., 2011)**. It also affects the cell growth rate as well as interaction with ions and organic molecules. Or may be attributed the stimulation of metabolic processes or increased nutrient uptake provoked by microwave treatments.

The results of the growth media effects presented in Tables 1 indicated that the sand medium was significantly superior to other media in accelerating sprouting dates. This result may be attributed do you the sandy soil's physical properties significantly influence Freesia corm sprouting. Sandy soil's loose structure and large pores enhance drainage, aeration and water infiltration. This well-oxygenated environment promotes healthy root growth, facilitating nutrient uptake essential for sprouting (**Hartmann *et al*., 2018; Kulkarni *et a*l., 2019; & Mendonça *et al*., 2020).** This result agreed with **Badawy (1998)** and **Abd El Sattar *et al*., (2010)** on *Polianthes tuberosa* plant.

Peat moss increases the number of florets per spike in Freesia plants as shown in Table 4 by providing optimal growing conditions. Its high water-holding capacity maintains consistent moisture, reducing stress and promoting healthy growth. The acidic pH (3.5-4.5) enhances nutrient availability, particularly micronutrients essential for flower development. Peat moss also fosters robust root growth, efficient nutrient uptake and potentially stimulates cytokinin production, promoting cell division and flower initiation. Consequently, incorporating 20-50% peat moss into potting mixes can increase florets per spike by 15-25%, according to research **(De Waard, 2017; Kulkarni *et al*., 2019)**. The same findings were confirmed by **Lee (2016)** on Freesia and **Hassan *et al*. (2016)** on gladiolus, who displayed that the growth substrate comprised of peat moss significantly increased vegetative characteristics, flowering, and corm production of plants in comparison with other media.

Moreover, the planting corms in a mixture peat moss + sand significantly increase plant height, number of corms per plant, vase life of cut flower and number of produces Cormles, as shown in tables 2, 3, 5 and 6. This result may be due to peat moss and sand mixture optimize Freesia growth. Peat moss retains moisture, reduces stress and promotes root growth, while sand enhances drainage, preventing waterlogging. This blend increases plant height, extends vase life and boosts corm and cormels production due to improved nutrient uptake and water availability **(Reed., 2017; & Singh & Sharma, 2020).** This result agrees with **Nasr (2000)** on tuberose plant, concluded that sand/composted leaves medium resulted in significant increase in bulbs yield and fresh and dry weights of produced bulblets**. El-Sayed *et al*., (2012)** on Freesia refracta cv. "Red Lion", concluded that growing cormlets in sand/sewage sludge medium (3:1 v/v) gave rise, to some extent corms yield, fresh weight of new corms, corms circumference and fresh weight of cormlets.

Conclusion

In conclusion, this study demonstrates that both microwave radiation and the choice of growth media significantly impact the productivity and overall health of *Freesia hybrida* plants. Specifically, medium intensity microwave exposure for 15 seconds and planting in a peat moss-sand mixture resulted in optimal growth and quality parameters, indicating that these practices may enhance commercial production of Freesia. Future research should explore the long-term effects of these treatments and optimize conditions for even greater efficiency in Freesia cultivation.

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