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Effect of Different Type Light and Growing Medium on the Growth and Flowering of Two Cultivars of Carnation (*Dianthus caryophyllus* L.)

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Abstract: This study was carried out in the greenhouse of the Horticulture Department Nursery, College of Agriculture Engineering Sciences, Duhok University, Kurdistan region, Iraq, for the period from 1st Aug 2020 to 1st Mar 2021, to study the effect of five supplemental light (control, natural light, Incandescent 14, Incandescent 18, mixed 14, mixed 18) hours daily and three growing medium (river soil, river soil + 30% local compost, river soil + 60% local compost) on some vegetative growth and flowering of two cultivars of carnation plant. The best results (fewest days) for the number of days from planting to bud emergence, visible flower colour, and anthesis were obtained when the plants were exposed to mixed light colours or incandescent lamps for a 14-hour treatment, Also this treatments were significantly superior in the other characteristics like plant height, flower length and flower diameter compared to the control. Medium with 60% local compost significantly increased all the studied characteristics compared with other mediums. The Ormea (Red) cultivar was significantly superior to the Moonlight cultivar in all studies of characteristics and was early in day numbers for bud emergence, visible flower colour, and anthesis. All second interactions between the investigated factors had a significant influence in all studied characteristics. In addition, the triple interaction between the three factors had a significant impact on all characteristics, including the least days or fewest days to flower anthesis of the Ormea cultivar when planted on medium containing 60% local compost under incandescent 14h, which took 101.80 days compared 176.27 days, with an early reach of 74.47 days for the control. The Moonlight (white) cultivar required the fewest days, 128.93 days, for a medium containing 60% compost under mixed 14h, which needed 123.93 days, compared to the control, which required 195.87 days with an early flowering rate of 71.94 days.

Key words: Carnation plant, Cultivars, Growing medium, Type of light.

Introduction

Carnation plant *Dianthus caryophyllus* L. is a member of the Caryophylaceae family. Some carnation varieties are annual, biennial, or perennial. They are used as bedding plants and for cut flower production (Dole & Wilkins, 2005). The common name for the genus *Dianthus* is carnation plant. Distribution of carnation plant is likely to have originated from the Mediterranean regions of Greece and Italy (including Sicily and Sardinia), but the long time in cultivation makes it difficult to confirm its precise origin (Tutin & Walters, 1993). Carnation is a major floricultural crop that is widely cultivated for cut flowers and as ornamental plants in gardens; in 2013, it was ranked as the 16th most popular cut flower, with a turnover of €24 million, compared to the flower rose, which was ranked first with a turnover of €780 million (FloraHolland, 2014; Ahmed *et al.,* 2018). Although carnations are sold all-year round, they are especially in demand for Valentine's Day, Easter, Mother's Day, and Christmas. While standard carnations are more popular, miniature carnations have quickly gained popularity for their potential use in floral arrangements and as a cut flower at a low cost (Nowak & Rudnicki, 1990). Modern carnation cultivars offer a diversity of colours, shapes, and sizes not available in other flowering plants. They are cultivated on a large scale in the Mediterranean region. However, it can be produced all over the world in greenhouses (El-Naggar, 2009).

Flower initiation in carnations occurs when the plant has 18 pairs of leaves (Whealy, 1992). It usually blooms during the summer, when the days are long. Flower bud development is enhanced by high light intensity. Twenty to 30 long-days are required under low light and seven to 14 days under high light intensities. A good supply of light is required for high-quality flower formation. Extremely high light intensity, which exceeds the photosynthetic capability of the plants, results in photo-inhibition, pale foliage and flowers, whilst it is also possible that plants will become burnt, The limitation of photoprotection mechanisms in the leaf and the results observed after the transfer of plants from 22.5% to 90% reinforce the possibility that a photoinhibition is reflected in a decrease in growth rate. (Stancato *et al*., 2002).

In order to grow cut flowers over a wide range of seasons throughout the year, it becomes readily apparent that crop management and growth techniques must be periodically modified if maximum yields are to be obtained despite the differing climatic factors like light and temperature (Cermeno *et al*., 2001). The growing medium is one of the most important factors that plays a key role in the quality and quantity of carnation flower production (Nelson, 1991).

Yasmeen *et al*. (2012) found that commercial varieties of carnation plants grow and flower in parameters such as plant height, number of branches per plant, length of branches, number of leaves per plant, leaf area (cm^2), least days to first flower emergence, number of flowers per plant, flower diameter (cm) and quality of the flowers showed good results in silt and garden soil (river soil), but overall, leaf compost + sand showed the best results, while farmyard manure with higher pH produced the least results regarding all plant parameters. Asghari (2014) found that growth and flowering such as flower length (cm), flower diameter (cm), stem length (cm) and longevity (day) exhibited the best media are the media that content 20%-40% vermicompost in compounding with soil or perlit. Al-Sahaf & Al-Zurfi (2016) found that application of wheat residues compost at a level of 5% led to an increase in the number of leaves (143.33 and 115.67 $leaf.plant^{-1}$), a reduction in the number of days to flowering (206.7 and 205.0 days for both seasons respectively), while the application of wheat residues compost at a level of 10% to the Ormea cultivar increased leaf area (508.4 and 669.4 cm^2), flower diameter

(5.26 and 6.06 cm), vase life 5.67 and 7.33 days, respectively.

Supplementary light is the only way to increase the day length to enhance plant growth and development in horticulture (Currey & Lopez, 2013; Wallace & Both, 2016). Recently, LEDs have been successfully tested for their ability to allow the growth of agronomically important crops, fruit and flower plants, and even trees (Astolfi *et al*., 2012; Sabzalian *et al*., 2014). Therefore, supplementary lighting is an important horticultural strategy to improve crop growth, maintain high yields all year round, and produce superior-quality plants (Zheng & Van Labeke, 2018). Also, photoperiod may affect reproductive development and flowering, as well as a few other metabolic processes (Singh *et al*., 2015). Another key element impacting bud sprouting is the quality of light. It is widely known that plants do not absorb all wavelengths at the same rate, and that abiotic stresses such as light can affect secondary metabolite production (Yeum & Russell, 2002; Kopsell *et al*., 2005).

Primary metabolic reactions such as photosynthesis are known to be aided by blue and red wavelengths, while blue and high R: FR ratios cause chloroplast growth and change density (Tlalka *et al*., 1999). Red wave and deficiency can lower overall yields and photosynthetic rates (Olle & Viršile, 2013). Flower bud growth and the rate of floral induction in carnations are boosted by high light intensity. Therefore, there is an interaction between the amount of ambient light and the number of long days for flower initiation in carnations (Biondo & Noland, 2000; Dole & Wilkins, 2005). Supplemental lighting during low light periods can increase vegetative growth and development and enhance flowering (Anthura, 2010). The application time of short day was also studied where covering from 5h to 9h AM was found to be the best treatment for flowering (Nxumalo & Wahome, 2010).

Photoperiod duration was also studied by some researchers. The submission of C. morifolium cv. Reagan Sunny to three photoperiods including 8, 10 and 12 hours at flower bud initiation and flower bud development stages showed a positive effect for 8h in promoting flower initiation, and buds did not develop into flowers under 12h (Kahar, 2008). Through research conducted by Thakur & Grewal (2018) on the effect of artificial lighting and shortening the night on a plant Chrysanthemum cv. cultivar Snowball, as it showed a noticeable effect on several vegetative and flowering characteristics such as plant height and the number of leaves, which reached (45 cm, 60 leaves) respectively compared to untreated plants (24.25 cm, 47.83 leaves). In addition to the significant difference in the full blooming of the flower (135.72days) compared to the control treatment (108.22 days). This study aimed at:

i.Timing the year-round production of carnation cut flowers by using many treatments of supplemental lighting (incandescent and mixed for 14 and 18 hours)

ii.Determining the best level of local compost for best growth and flowering for two cultivars of carnation plants.

Materials & Methods

The study was carried out in the glasshouse of the Horticulture Department nursery, College of Agriculture Engineering Sciences, Duhok University. Kurdistan region, Iraq, for the period from 1st August, 2020 to 1st March, 2021.

To study the effects of supplemental light, which includes five kinds [natural light (control), mixed light (blue, green, and red) for

14 h, mixed light (blue, green, and red) for 18 h, incandescent light for 14h, incandescent light for 18h] daily, starting at 6 PM for a 14 and 18h period.

Three growing medium (river soil, river soil + 30% local compost, river soil + 60% local compost) by volume on the growth and flowering of two cultivars of carnation plant (Ormea and Moonlight) cultivars. Local compost is a mixture of (sheep manure: sawdust: hay: and lawn grass clippings, 2:1:1:1) by volume. Prepared by mixing the main components of the medium in an underground place (large hole), then adding some catalysts or stimulants, 50 g of dry yeast bread, 0.5 kg of urea, and 0.5 kg of table sugar per each cubic meter, the mixture is watered until saturation status and covered with polyethylene plastic tightly with constant stirring every 15–20 days. After 90 days from the start of the fermentation process, the medium becomes ready for use as an agricultural medium.

The chemical characteristics of the river soil and local compost receptively are pH 7.81, 7.72, Ec 0.328, 0.342 $ds.m^{-1}$, Co_3 1.6, 3 $mmol.l^{-1}$, k, 0.29, 109.0 $mg.l^{-1}$, P 7.17, 103.03 $mg.l^{-1}$, N 63, 98 $mg.l^{-1}$, Soil texture: sandy 50.5%, clay 31.5%, loam 18.0%, organic matter 1.17, 5.47%. Rooted cuttings of one month old of the two cultivars obtained from Antalya nursery in Turkey were planted in pots of 5 liters by using the three growing medium which were determined in this study. After two weeks from planting, the pinched to three nodes were done, and the lighting treatment started on September 1st for three months by installing an iron frame divided into four parts by using thick black clothes to separate the five lighting treatments, which were installed by using blue, green, and red lamps for mixed light treatment and incandescent lamps for other kinds, and using an electric timer to control the timing factor. In this study, the natural light (control) was left out of the frame.

Statistical analysis

This experiment was performed using a split-split plot design, and the data was analyzed by using a computer through the SAS program, and the means comparison was done using DMRT under 5% (SAS, 2013).

So, the experiment includes three factors: three replicates, and five plants for each replicate, 5×3×2×3×5= 450 plants in pots of five liters. The studied characteristics include the number of days from planting to flower bud emergence; the number of days from planting to visible flower colour; and the number of days from planting to anthesis (flower maturity). Plant height (cm), flower length (cm), and flower diameter (cm).

Results

The number of days from planting to flower bud emergence

Data in table (1) show that the two kinds of light Incandescent and mixed for 14 hours advance the flower bud emergence significantly, to 120.52 and 130.74 days, respectively, compared with natural light, which recorded 156.79 days. When compared to each other, the two types of supplementary light for 18 hours delayed flowering emergence by 168.59 and 169.08 days, respectively. The medium containing 60% compost decreased the number of days to flower bud emergence significantly to 142.96 days compared with 0 and 30% compost, which needed 159.45 and 145.02 days, respectively.

The Ormea cultivar needs fewer days to flower bud emergence 143.04 days compared with the Moonlight cultivar that needs 155.25 days with significant deference.

Less significant day for flower bud emergence as a result of the interaction between light and cultivar was found for the Ormea cultivar under the Incandescent 14h 105.22 day. While the highest day was for the Moonlight cultivar under Incandescent 18h and mixed 18h, 170.22 and 170.61 days, respectively, the natural light needed 162.79 days for flower bud emergence. In the case of interaction between supplemental light and medium treatments, the best interaction was for incandescent 14h and medium with 60% compost, which significantly decreased the day to flower bud emergence to 106.57 days compared with the highest number of days that were found under the mixed 18h and 0% compost 170.40 days. The results of the interaction between the medium and the cultivar were significant. The highest day to flower bud emergence was for the Moonlight cultivar grown in medium containing 0% compost compared with the lower day of 135.46 days (best interaction) which was obtained for the Ormea cultivar grown in 60% compost.

Concerning the combination of the three factors (supplemental light, medium, and cultivars), it was demonstrated that the Ormea and Moonlight plants grown under Incandescent 14h and in 60% compost, which recorded 85.80 and 124.9 days, respectively, had fewer days to flower bud emergence. The highest day to flower bud emergence of two cultivars was 175.93 for the Ormea cultivar under natural day and grown in river soil, while for the Moonlight cultivar it reached 171.22 days when planted under mixed light and river.

The number of days from planting to visible flower colour

Data in table (2) clearly shows that incandescent and mixed light for 14h also advance the visible flower colour significantly to 132.87 and 140.59 days compared with control (natural light) which recorded 166.92 days. Whereas two types of supplemental lighting for 18 hours delay visible flower colour by 176.06 and 177.57 days, respectively. The growing medium with 60% compost caused a significant decrease in visible flower colour and took 152.08 days compared with river soil (without compost) and 30% compost, which needed 168.52 and 155.81 days, respectively. The Ormea cultivar needs 152.14 days to reach visible flower colour compared with the Moonlight cultivar that needs 155.25 days with significant deference.

The first dual interaction between light and cultivars significantly decreased the number of days to visible flower colour and the least value was 118.85 days for the Ormea cultivar grown under Incandescent 14h while the highest number of days was for the Moonlight cultivar, which was lighted with incandescent 18h and mixed 18h, 180.01 and 180.68 respectively. The second dual interaction between Medium and the cultivar was significant. The lowest number of days to visible flower colour was for the Ormea cultivar grown in medium that contained 60% and 30% compost, 143.88 and 149.11 days, respectively. While the highest number of days (174.61) was for the Moonlight cultivar in medium without compost. The third dual interaction between light and medium caused a significant decrease in the number of days of visible flower colour. The plants under Incandescent 14h light and grown in medium had a 60% compost decrease in the number of days to visible flower colour, to 115.61 days, compared with the highest number of 179.96 days for the plants under mixed 18h and grown in medium containing 0% compost (river soil only).

Table (1): Effect of light and growing medium on day number from planting to flowers Bud emergence of two cultivars of carnation plant.

Light	Cultivars	Medium			Light × cultivars	Light effect
		River soil	30% compost	60% compost		
Natural	Moonlight	175.93±3.09^{a}	155.00±5.21^{f}	156.40±6.29^{f}	162.44±4.21^{c}	156.79±2.75^{b}
	Ormea	156.27±1.48^{f}	149.53±5,31^{g}	147.60±±5.14^{g}	151.1±2.54^{d}	
Mixed 14	Moonlight	157.00±4.63^{f}	129.53±2.19^{i}	124.93±2.52^{ij}	137.15±5.27^{e}	130.74±4.19^{c}
	Ormea	146.80±2.70^{f}	116.87±4.97^{k}	109.33±4.07^{l}	124.33±6.06^{f}	
Incandescent 14	Moonlight	146.40±0.0^{g}	133.7±4.46^{h}	127.33±1.57^{ij}	135.81±3.11^{e}	120.52±5.52^{d}
	Ormea	136.00±0.0^{h}	93.87±1.55^{m}	85.80±3.33^{n}	105.22±7.85^{g}	
Mixed 18	Moonlight	169.59±0.30^{b-e}	169.59±1.33^{b-e}	172.65±0.61^{ab}	170.61±0.67^{a}	169.08±0.75^{a}
	Ormea	171.22±0.82^{bc}	164.9±2.22^{e}	166.52±0.53^{c-e}	167.55±1.18^{b}	
Incandescent 18	Moonlight	169.28±0.53^{b-e}	170.40±1.08^{b-d}	170.97±0.85^{bc}	170.22±0.49^{a}	168.59±0.69^{a}
	Ormea	166.03±2.40^{de}	166.83±2.01^{c-e}	168.05±1.70^{b-e}	166.97±1.07^{b}	
Natural	Light × medium	166.10±4.66^{a}	152.27±3.54^{b}	152.00±4.13^{b}	cultivars effect	
Mixed 14		151.90±3.31^{b}	123.20±3.72^{d}	117.13±4.09^{e}		
Incandescent 14		141.20±2.32^{c}	113.79±9.15^{e}	106.57±9.43^{f}		
Mixed 18		170.40±0.53^{a}	167.25±1.56^{a}	169.59±1.41^{a}		
Incandescent 18		167.65±1.31^{a}	168.62±1.30^{a}	169.51±1.07^{a}		
Medium × cultivar	Moonlight	163.64±2.98^{a}	151.64±4.79^{c}	150.46±5.64^{c}	155.25±2.75^{a}	
	Ormea	155.26±3.48^{b}	138.40±7.76^{d}	135.46±8.81^{e}	143.04±4.19^{b}	
Medium effect		159.45±2.38^{a}	145.02±4.64^{b}	142.96±5.32^{c}		

* Means with same letter for each factor and interaction are not significantly different at 5% level based on Duncan's Multiple Rang Test

Concerning the combination of three factors (light, medium, and cultivars), the table (2) revealed that the lowest number of days to visible flower colour, 93.22 days, was observed in plants of the Ormea cultivar grown under Incandescent 14h and 60% compost, while the highest day reached 185.93 days for the Moonlight cultivar grown in river soil medium and under natural light

The number of days from planting to anthesis (flower maturity)

The number of days to anthesis in table (3) recorded significantly decreased as a result of the supplemental light effect. The Incandescent 14h advanced the flower anthesis to 140.50 days, followed by the mixed 14h to 150.30 days compared with control (natural light), which needed 175.47 days, and the Incandescent 18h and mixed 18h, which needed 188.79 and 190.41 days respectively. The medium containing 60% compost also significantly decreased flower anthesis to 163.26 days faster than river soil with 0% compost, which needed 179.87 days. The Ormea `cultivar demonstrated early flower anthesis of 161.43 days compared with the Moonlight cultivar of 176.75 days.

The first dual interaction between light and cultivars had a significant effect on the number of days to flower anthesis. The least number of 124.87 days was for the Ormea cultivar under Incandescent 14h, while the largest number of days to anthesis was for the Moonlight cultivar under Incandescent 18h, 194.57 days. The second dual interaction between light and medium caused a significant deference in the number of days to anthesis and the plants under Incandescent 14h and medium 60% promoted the flower anthesis to 125.30 days compared with the less interaction effect of Incandescent18 and 60% compost, which increased the number of days to 192.51.

The third dual interaction between medium and cultivar caused a significant effect on the day of flower anthesis. The best interaction was for the Ormea cultivar with 60% and 30% compost, which needed 154.13 and 155.28 days. The Moonlight cultivar and 0% compost required the longest time, at 184.84 days. Concerning the combination between the three factors, the number of days to flower anthesis was promoted to 101.80 days for the Ormea cultivar subjected to Incandescent 14h and grown in medium containing 60% compost, compared with the highest number of 191.03 days for the same cultivar but grown under mixed 18h in medium consisting of 0% compost only (river soil), whereas for the Moonlight cultivar the best interaction was for flower anthesis needed 148.80 days cultivated on medium with 60% compost under Incandescent 14h, compared with the same cultivar that was grown in natural light and river soil, which needed 195.87 days to flower anthesis

Plant high

The data in table (4) clarified that incandescent lamps for 14h increased the plant's height significantly by 77.44 cm, followed by mixed lamps for 14h by 72.54 cm compared with control (natural light), which recorded the lowest height of the plant at 68.18 cm. Also, the medium containing 60% compost increased the plant height significantly, reaching 74.23 cm, compared with the lower value of 67.97 cm for 0% compost (control). The Ormea cultivar gave a height of plant of 78.82 cm, compared with the Moonlight cultivar's 62.21 cm. The interaction between the supplemental light and the cultivars recorded a significant difference in this characteristic.

Table (2): Effect of light and growing medium on the number of days from planting to visible flower colour of two cultivars of carnation plant.

Light	Cultivars	Medium			Light × cultivars	Light effect
		River soil	30% compost	60% compost		
Natural	Moonlight	185.93±0.09[a]	165.00±5.21[e-g]	166.40±6.29[e-g]	172.44±4.21[b]	166.92±2.76[b]
	Ormea	166.27±1.48[e-g]	160.20±5.97[gh]	157.73±5.26[h]	161.40±2.66[c]	
Mixed 14	Moonlight	166.13±4.75[e-g]	140.53±1.97[jk]	135.27±2.83[k]	147.31±5.05[d]	140.59±4.22[c]
	Ormea	156.87±2.73[h]	126.87±5.11[l]	117.87±4.10[m]	133.87±6.24[e]	
Incandescent 14	Moonlight	156.33±0.30[h]	146.33±5.08[ij]	138.00±1.91[k]	146.89±3.08[d]	132.87±5.60[d]
	Ormea	148.00±0.33[i]	115.33±11.70[m]	93.22±1.51[n]	118.85±8.65[f]	
Mixed 18	Moonlight	180.46±0.23[ab]	180.35±0.39[ab]	181.24±0.0[ab]	180.68±0.22[a]	177.57±0,99[a]
	Ormea	179.47±0.38[ab]	170.97±0.55[d-f]	172.96±0.58[cd]	174.46±1.30[b]	
Incandescent 18	Moonlight	179.20±0.37[ab]	180.35±0.24[ab]	180.47±0.43[ab]	180.01±0.27[a]	176.06±1.26[a]
	Ormea	166.51±1.09[e-g]	172.19±0.75[c-e]	177.63±0.63[bc]	172.11±1.66[b]	
Natural	Light × medium	176.10±4.66[a]	162.60±3.70[b]	162.07±4.15[b]	cultivars effect	
Mixed 14		161.50±3.20[b]	133.70±3.92[d]	126.57±4.49[de]		
Incandescent 14		152.17±1.87[c]	130.83±8.98[de]	115.61±10.07[f]		
Mixed 18		179.96±0.30[a]	175.66±2.12[a]	177.10±1.87[a]		
Incandescent 18		172.85±2.88[a]	176.27±1.86[a]	179.05±0.72[a]		
Medium × cultivar	Moonlight	173.61±3.04[a]	162.51±4.63[bc]	160.28±5.59[c]	165.47±2.67[a]	
	Ormea	163.42±2.87[b]	149.11±6.72[d]	143.88±8.88[e]	152.14±3.95[b]	
Medium effect		168.52±2.26[a]	155.81±4.20[b]	152.08±5.34[c]		

Table (3): The effect of light and growing medium on the number of days between planting and anthesis of two carnation cultivars.

Light	Cultivars	Medium			Light × cultivars	Light effect
		River soil	30% compost	60% compost		
Natural	Moonlight	195.87±3.04^{a}	172.53±4.10^{h}	175.33±5.84^{gh}	181.24±4.30^{c}	175.47±2.87^{b}
	Ormea	176.27±1.58^{gh}	168.27±5.27^{i}	164.53±5.51^{i}	169.69±2.83^{d}	
Mixed 14	Moonlight	177.13±4.86^{fg}	149.87.±1.80^{k}	145.00±2.62^{l}	157.33±5.25^{e}	150.30±4.17^{c}
	Ormea	164.73±3.07^{i}	136.13±4,68^{m}	128.93±4.30^{n}	143.26±5.83^{f}	
Incandescent 14	Moonlight	165.33±1.27^{i}	154.27±4.76^{j}	148.80±0.20^{kl}	156.13±2.81^{e}	140.50±6.26^{d}
	Ormea	164.00±0.30^{i}	108.80±1.24^{o}	101.80±2.69^{p}	124.87±9.87^{g}	
Mixed 18	Moonlight	192.54±0.31^{a-c}	194.56±0.46^{ab}	196.34±0.42^{a}	194.48±0.59^{a}	190.41±1.24^{a}
	Ormea	191.03±0.41^{bc}	181.18±53^{ef}	186.78±0.39^{d}	186.33±1.44^{b}	
Incandescent 18	Moonlight	193.32±0.52^{ab}	193.94±0.38^{ab}	196.45±0.27^{a}	194.57±0.52^{a}	188.79±1.60^{a}
	Ormea	178.46±0.76^{e-g}	182.01±0.63^{e}	188.58±0.28^{cd}	183.01±1.51^{c}	
Natural	Light × medium	186.07±4.64^{c}	170.40±3.13^{d}	169.93±4.33^{d}		
Mixed 14		170.93±3.71^{d}	143.00±3.80^{f}	136.97±±4.24^{g}		
Incandescent 14		164.67±0.65^{e}	131.53±10.40^{h}	125.30±10.58^{i}	cultivars effect	
Mixed 18		191.78±0.41^{ab}	187.87±3.00^{bc}	191.56±2.15^{ab}		
Incandescent 18		185.89±3.34^{c}	187.97±2.69^{bc}	192.51±1.77^{a}		
Medium × cultivar	Moonlight	184.84±3.29^{a}	173.03±5.18^{c}	172.39±6,03^{c}	176.75±2.93^{a}	
	Ormea	174.90±2.73^{b}	155.28±7.73^{d}	154.13±9.13^{d}	161.43±4.25^{b}	
Medium effect		179.87±2.29^{a}	164.16±4.86^{b}	163.25±5.64^{b}		

Table (4): Effect of light and growing medium on the plant high (cm) of two cultivars of carnation plant.

Light	Cultivars	Medium			Light × cultivars	Light effect
		River soil	30% compost	60% compost		
Natural	Moonlight	60.58±2.76^{h-k}	63.10±0.32^{f-k}	60.36±1.08^{h-k}	61.35±0.97^{c}	68.18±1.98^{b}
	Ormea	70.06±3.15^{d-i}	78.83±2.68^{b-d}	76.12±3.44^{b-d}	75.00±2.02^{ab}	
Mixed 14	Moonlight	57.78±4.59^{k}	62.35±5.60^{g-k}	74.32±2.93^{b-f}	64.82±3.34^{c}	72.54±2.70^{b}
	Ormea	72.95±2.47^{c-g}	82.52±2.81^{a-c}	85.30±1.59^{ab}	80.26±2,20^{a}	
Incandescent 14	Moonlight	69.85±4.52^{d-j}	77.15±3.83^{b-d}	74.77±2.11^{b-e}	73.92±2.11^{b}	77.44±2.02^{a}
	Ormea	71.02±1.57^{c-h}	80.45±3.27^{a-c}	91.38±0.79^{a}	80.95±3.13^{a}	
Mixed 18	Moonlight	60.78±3.73^{h-k}	57.62±3.34^{k}	59.38±3.13^{i-k}	59.26±1.76^{c}	68.64±2.48^{b}
	Ormea	76.93±1.83^{b-d}	76.78±2.09^{b-d}	80.33±0.48^{a-c}	78.01±0.99^{ab}	
Incandescent 18	Moonlight	63.08±4.37^{f-k}	63.72±4.24^{e-k}	58.30±2.82^{jk}	61.70±2.11^{c}	70.78±2.54^{b}
	Ormea	76.70±3.45^{b-d}	80.87±1.07^{a-c}	82.00±2.78^{a-c}	79.86±1.54^{ab}	
Natural	Light × Medium	65.32±2.82^{e}	70.97±3.71^{cd}	68.24±3.88^{de}	cultivars effect	
Mixed 14		65.37±4.11^{e}	72.43±5.30^{c}	79.81±2.87^{ab}		
Incandescent 14		70.43±2.16^{cd}	78.80±2.37^{b}	83.08±3.85^{a}		
Mixed 18		68.86±4.04^{cde}	67.20±4.64^{de}	69.86±4.90^{cd}		
Incandescent 18		69.89±3.93^{cd}	72.29±4.30^{c}	70.15±5.59^{cb}		
Medium × cultivar	Moonlight	62.41±1.88^{c}	64.79±2.28^{c}	65.43±2.21^{c}	64.21±1.21^{b}	
	Ormea	73.53±1.24^{b}	79.89±1.07^{a}	83.03±59^{a}	78.82±0.95^{a}	
Medium effect		67.97±1.51^{c}	72.34±1.87^{b}	74.23±2.11^{a}		

The highest plant height was 80.95 cm for the Ormea cultivar subjected to Incandescent 14h. While the lowest plant height of 59.26 cm was for the Moonlight cultivar under mixed light (18 hours), compared with natural light for the Moonlight cultivar that reached only 61.35 cm. The dual interaction between supplemental light and medium recorded a significant difference in this characteristic. The highest plant height was obtained under incandescent light for 14 hours and medium with 60% compost for 83.08 cm compared with the lowest plant height under natural light and 0% compost for 65.32 cm. The results of the interaction between the medium and the cultivar were significant. Noted in table (1) was the highest plant in the medium, 60% compost. 83.03 cm was obtained in the Ormea cultivar. The Moonlight cultivar had the lowest plant height in medium with 0% compost, measuring 62.42 cm.

Concerning the interaction between all studied factors, the highest plant height was for Ormea cultivar plants grown under incandescent lamps for 14h and 60% compost at 91.38 cm. This increase was significantly compared with the majority of treatments, whereas the lowest plant height was 57.62 cm for the Moonlight cultivar grown in river soil medium and under mixed 18h light

Flower lengths of two carnation cultivars

Table (5) shows a significant influence of the supplemental light on the flower length of carnation plants. The best significant result was recorded for incandescent lamps at 14h 67.00 cm, followed by a mixed 14h 62.77 cm compared with natural light, which gave 58.29 cm. The Ormea cultivar in a growing medium containing 30% and 60% compost increased flower length significantly to 62.22 and 63.14 cm, respectively, compared with 0% compost (river soil) that gave the lowest mean of 59.15 cm. The Ormea cultivar gives the best flower length of 68.05 cm, compared with the Moonlight cultivar's 54.96 cm.

The interaction between supplemental light and cultivars increased flower length significantly, with the highest flower lengths of 69.98 cm and 69.18 cm obtained for the Ormea cultivar grown under incandescent lamps for 14 h and mixed lamps for 14 h, respectively, and the lowest flower lengths obtained for the Moonlight cultivar grown under mix18 and natural light, 51.01 and 51.34 cm. In the case of interaction between different lights and different media, the flower length under incandescent 14h and medium 60% caused a significant increase, reaching 70.78 cm compared with the lower flower length under natural light, 55.96 cm, and river soil. The results of the interaction between the medium and the cultivar were significant. The best flower length was for Ormea cultivar plants grown in medium containing 60%, followed by 30% compost, at 70.93 and 68.56 cm, respectively. While the shorter flower length of 55.35 cm was for the Moonlight cultivar obtained in the growing medium of 60% compost.

Concerning the interaction between the three factors, the highest flower length, 77.17 cm, was for Ormea cultivar plants when cultivated in 60% compost and under Incandescent 14h. This increase was significant when compared with most treatments. Whereas the lowest flower length was 48.25 cm for Moonlight cultivar plants cultivated on medium containing 60% compost and under incandescent 18-hour light.

Table (5). Effect of light and growing medium on the flower length (cm) of two cultivars of carnation plant.

Light	Cultivars	Medium			Light × cultivars	Light effect
		River soil	30% compost	60% compost		
Natural	Moonlight	51.47±3.14[gh]	53.13±0.27[f-h]	49.42±1.34[gh]	51.34±1.13[b]	58.29±1.90[c]
	Ormea	65.73±1.51[a-e]	63.20±2.27[b-f]	66.80±3.35[a-d]	65.24±1.36[a]	
Mixed 14	Moonlight	48.79±4.09[h]	55.45±4.95[d-f]	64.82±2.66[c-g]	56.35±3.07[b]	62.77±2.33[b]
	Ormea	63.13±2.29[b-f]	71.23±2.45[a-c]	73.17±1.58[ab]	69.18±1.87[a]	
Incandescent 14	Moonlight	60.40±4.04[d-g]	67.27±3.77[a-c]	64.40±2.31[b-f]	64.02±1.99[a]	67.00±2.15[a]
	Ormea	60.80±1.41[d-g]	71.98±2.27[a-c]	77.17±9.20[a]	69.98±3.67[a]	
Mixed 18	Moonlight	54.50±3.63[e-g]	48.65±2.89[h]	49.88±2.70[gh]	51.01±1.79[b]	59.45±2.28[bc]
	Ormea	66.93±1.88[a-d]	67.13±2.49[a-d]	69.60±0.53[a-c]	67.89±1.00[a]	
Incandescent 18	Moonlight	53.08±4.37[f-h]	54.87±5.39[e-h]	48.25±2.04[h]	52.07±2.31[b]	60.01±2.30[bc]
	Ormea	66.67±3.46[a-d]	69.25±0.95[a-c]	67.92±1.23[a-c]	67.94±1.15[a]	
Natural	Light × medium	58.60±3.55[bc]	58.17±2.47[bc]	58.11±4.20[bc]	cultivars effect	
Mixed 14		55.96±3.83[c]	63.34±4.31[b]	68.99±2.32[a]		
Incandescent 14		60.60±1.92[bc]	69.63±2.23[a]	70.78±5.11[a]		
Mixed 18		60.72±3.32[bc]	57.89±4.47[bc]	59.74±4.58[bc]		
Incandescent 18		59.88±3.92[bc]	62.06±4.04[b]	58.08±4.52[bc]		
Medium × cultivar	Moonlight	53.65±1.97[c]	55.87±2.21[c]	55.35±2.20[c]	54.96±1.18[b]	
	Ormea	64.65±1.05[b]	68.56±1.18[ab]	70.93±1.97[a]	68.05±0.91[a]	
Medium effect		59.15±1.44[b]	62.22±1.70[a]	63.14±2.04[a]		

Table (6): Effect of light and growing medium on the flower diameter (cm) of two cultivars of carnation plant.

Light	Cultivars	Medium			Light × cultivars	Light effect
		River soil	30% compost	60% compost		
Natural	Moonlight	6.49±0.05^{f-l}	6.89±0.11^{c-h}	6.13±0.27^{l}	6.50±0.13^{d}	6.69±0.08^{b}
	Ormea	6.90±0.18^{c-g}	6.91±0.10^{c-g}	6.83±0.18^{c-j}	6.88±0.06^{c}	
Mixed 14	Moonlight	6.32±0.15^{kl}	6.26±0.12^{kl}	6.99±0.10^{c-f}	6.52±0.13^{d}	6.84±0.11^{ab}
	Ormea	6.94±0.09^{c-f}	7.06±0.05^{b-d}	7.50±0.07^{b}	7.17±0.09^{b}	
Incandescent 14	Moonlight	6.24±0.93^{kl}	6.32±0.29^{kl}	6.58±0.11^{d-l}	6.38±0.10^{d}	6.98±0.20^{a}
	Ormea	6.88±0.03^{c-h}	7.20±0.13^{bc}	8.64±0.08^{a}	7.57v0.27^{a}	
Mixed 18	Moonlight	6.37±0.15^{i-l}	6.31±0.35^{kl}	6.67±0.08^{d-k}	6.45±0.12^{d}	6.69±0.09^{b}
	Ormea	7.01±0.12^{c-e}	6.93±0.25^{c-g}	6.86±0.16^{c-i}	6.93±0.09^{bc}	
Incandescent 18	Moonlight	6.35±0.10^{j-l}	6.43±0.14^{g-l}	6.26±0.33^{kl}	6.35±0.11^{d}	6.39±0.07^{c}
	Ormea	6.34±0.11^{j-l}	6.54±0.21^{e-l}	6.39±0.27^{h-l}	6.42±0.10^{d}	
Natural	Light × medium	6.70±0.12^{bc}	6.90±0.07^{bc}	6.48±0.19^{bc}	cultivars effect	
Mixed 14		6.63±0.16^{bc}	6.66±0.18^{bc}	7.24±0.12^{ab}		
Incandescent 14		6.56±0.15^{bc}	6.76±0.24^{bc}	7.61±0.46^{a}		
Mixed 18		6.69±0.16^{bc}	6.62±0.24^{bc}	6.76±0.09^{bc}		
Incandescent 18		6.34±0.06^{d}	6.49±0.11^{bc}	6.33±0.19^{d}		
Medium × cultivar	Moonlight	6.35±0.05^{c}	6.44±0.10^{c}	6.53±0.11^{c}	6.44±0.05^{b}	
	Ormea	6.81±0.08^{b}	6.93±0.09^{b}	7.24±0.21^{a}	6.99±0.08^{a}	
Medium effect		6.58±0.06^{b}	6.68±0.08^{b}	6.89±0.13^{a}		

Flower diameter

In table (6), the significant differences were observed as a result of the influence of each factor alone. So, the flower diameter characteristics recorded a significant increase when produced under incandescent lamps for 14h; it reached 6.98 cm, compared with natural light, which recorded 6.69 cm, and less diameter for incandescent lamps for 18h, at 6.39 cm. Also, the growing medium containing 60% compost increased the flower diameter significantly to 6.89 cm compared with 0% compost, which gave 6.58 cm. The Ormea cultivar was significantly superior to the Moonlight cultivar in flower diameter; it gave 6.99 cm, whereas the Moonlight cultivar gave 6.44 cm.

The flower diameter for the Ormea cultivar increased significantly to 7.57 cm when grown under incandescent lamps for 14h, followed by mixed lamps for 14h, which reached 7.17 cm, whereas the lowest flower diameter was obtained for Moonlight and Ormea cultivars under incandescent lamps for 18h, at 6.42 and 6.35 cm. In the case of the interaction between different lights and different media, the flower diameter under Incandescent 14h and medium 60% caused a significant increase in flower diameter of 7.61 cm, but the lowest flower diameter was under Incandescent 18h and 60% compost, at 6.33 cm. The results of the interaction between the medium and the cultivar were significant. The highest flower diameter was found in the Ormea cultivar growing in medium containing 60% compost, at 7.24 cm. At the same time, the lowest flower diameters in medium with 0% compost were obtained on the Moonlight cultivar.

The triple interaction between the three factors indicated a significant difference in this characteristic. The highest flower diameter, 8.64 cm, was for the Ormea cultivar grown under Incandescent 14h and medium containing 60% compost. While the smaller flower diameter of 6.13 cm was for the Moonlight cultivar cultivated under natural light on medium containing 60% compost.

Discussions

The best results were obtained when the plants were lighted with mixed-colour or incandescent lamps for a 14-hour this may be attributed to the Supplementary light which enhance plant growth and development (Currey & Lopez, 2013; Wallace & Both, 2016), The significantly increased in some studied characteristics as a resulted led to an increase in plant height, the main stem diameter (Salih *et al*., 2020). In various long-day cut flowers, the effects of light quality on flowering were investigated. Yoshimura *et al.* (2002, 2006) used films to adjust light quality during the day and R-or FR-rich fluorescent lamps at night to demonstrate that a low R: FR ratio enhances flowering in *Matthiola incana*. Also, photoperiod may affect reproductive development and flowering, as well as a few other metabolic processes (Singh *et al*., 2015). Improving the light conditions and optimizing the phytochemical concentrations in vegetables produced in controlled environments enhances the growth and yield (Samuoliene *et al*., 2012). Flower bud growth and the rate of floral induction in carnations are boosted by high light intensity. Therefore, there is an interaction between the amount of ambient light and the number of long days for flower initiation in carnations (Biondo & Noland, 2000; Dole & Wilkins, 2005).

The significantly increased in all studied characteristics as a result to increase the local compost may be attributed to the important of growing mediums that play a key role in the quality and quantity of carnation flower production (Nelson, 1991). Its role is to enhance the physical and chemical properties of the soil, making it more suitable for the growth and activity of microorganisms. This is especially important for good drainage and aeration and water-holding capacity and reduces the frequency of irrigation. It also increases the decomposition of minerals from the major and minor elements and reduces the loss of N, P, K, and Mg from the container (Al Naime, 2000; Cabrera, 2004).

The Ormea (Red) cultivar was significantly superior to the Moonlight cultivar in most studied characteristics, these results might be attributed to genetic factors, different chemotypes and differences in the nutritional status of the plants as proven by Svecov & Neugebauerov (2010) whom found that the basil (Ocimum basilicum) cultivars displayed a wide diversity of morphological, biological and economic characteristics for the 34 studies cultivars.

Conclusions

The best growth and flowering of carnations was observed in this study when incandescent light was used for 14 hours on medium containing 60% compost for the Ormea cultivars, and the result showed a significant increase in most characteristics when compared to other treatments. Carnation production: the best growth and quality of the cut flowers under 14-hour light (mixed and incandescent) lamps

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Conflicts of Interest

The authors declare no conflicts of interest.

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L.S.M.A: Sample collection, Data collection, Write the manuscript.
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تأثير الضوء و الاوساط الزراعية على نمو وإزهار صنفين من القرنفل (*Dianthus caryophyllus* L)

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مستخلص : أجريت هذه الدراسة في البيت الزجاجي التابع لقسم البستنة– كلية علوم الهندسة الزراعية، جامعة دهوك، اقليم كوردستان، العراق للمدة من 2020/8/1 الى 2021/3/1 لبيان تاثير خمسة معاملات من الضوء الاضافي [معاملة المقارنة(الضوء الطبيعي) ، ضوء ابيض 14، ضوء ابيض 18، خليط الوان 14، خليط الوان 18] ساعة/يوم وثلاث اوساط زراعية (تربة النهر، تربة النهر + 30٪ سماد محلي، تربة النهر+ 60٪ سماد محلي) على بعض صفات النمو الخضري والإزهارلصنفين من نبات القرنفل هما (الاحمر) ormea و(الابيض) Moonlight ويمكن تلخيص اهم النتائج بمايلي .تم الحصول على أفضل النتائج أقل عدد للأيام من الزراعة إلى ظهور البراعم ، ظهور لون الزهرة ، والتفتح الكامل للازهارعندما تعرضت النباتات للضوء الابيض و خليط الالوان لمدة 14 ساعة وكانت هذه المعاملات متفوقة بشكل معنوي مقارنة مع معاملة المقارنة والمعاملات الأخرى. الوسط الذي يحتوي على 60٪ سماد محلي أدى إلى زيادة معنوية في جميع الصفات المدروسة مقارنة بالمعاملات الأخرى. تفوق الصنف الاحمر معنويا على الصنف الابيض في معظم الصفات المدروسة حيث بكر في ظهور البراعم وظهور اللون والتفتح الكامل. اظهرت جميع التداخلات الثنائية تاثير معنوي على معظم الصفات المدروسة، اظهر لتداخل الثلاثي بين العوامل تأثيرًا معنويًا في جميع الصفات وكان أقل عدد أيام لتفتح الأزهار للصنف الاحمرالمزروع في الوسط الذي يحتوي على 60٪ من السماد المحلي والمعرض للضوء الابيض لمدة 14 ساعة والتي احتاجت إلى 101.80 يومًا مقارنة مع النهار الطبيعي (المقارنة) والتي احتاجت إلى 176.27 يومًا وبتبكير وصل إلى 74.47 يومًا. في حين أن أقل عدد من الأيام بالنسبة للصنف الأبيض المزروع في الوسط الذي يحتوي على 60٪ سماد العضوي والمعرض الى 14 ساعة ضوء خليط حتاجت إلى 123.93 يومًا مقارنةً مع معاملة المقارنة والتي احتاجت إلى 195.87 يومًا وبتبكير وصل إلى 71.94 يومًا.

الكلمات المفتاحية: نبات القرنفل، الأصناف، الاوساط الزراعية، انواع الاضاءة.