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EFFECT OF PLANTING DATES, ALGAE EXTRACT AND NITROGEN FERTILIZER RATES ON THE GROWTH AND PRODUCTIVITY OF *CALENDULA OFFICINALIS* L. UNDER SANDY SOIL CONDITIONS

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ABSTRACT: A field experiment was set up at the Experimental Farm of the El-Quassassin Horticultural Research Station, Hort. Res. Inst., ARC., Ismailia Governorate, Egypt, during two winter seasons (2022/2023 and 2023/2024), with the aim to achieve the optimal growth and flowering productivity of marigold (*Calendula officinalis* L.). Three planting dates (September 15th, October 1st and October 15th) of 2022 and 2023, four combination treatments between nitrogen fertilizer and algae extract (algae extract (AE) at 3 ml/l, nitrogen at 100% of the recommended rate (RR), 50% RR of nitrogen + AE at 3 ml/l and 75% RR of nitrogen + AE at 3 ml/l) and their interaction treatments were tested. The obtained results indicated that the early sowing from September 15th followed by October 1st increased plant height, branches number per plant, fresh and dry weights of herb per plant, number of flowers per plant and flower diameter as well as chlorophyll a and b contents, phosphorus, potassium percentages and flowers fresh and dry weights per plant per season compared to the third planting date under sandy soil conditions. Applying nitrogen fertilization at 100% RR followed by 75% RR + AE at 3 ml/l treatments gave the highest values of abovementioned parameters. In general, planting pot marigold seedlings on September 15th followed by October 1st as well as fertilization with 100% RR of nitrogen or 75% RR of nitrogen + spraying with 3 ml/l of algae extract five times per season manifests to enhance growth, flower yield and chemical constituents of *Calendula officinalis* under Ismailia Governorate conditions. Also, the highest fresh and dry yield/fed/season were obtained from the combined treatment of growing date on October 1st as well as nitrogen fertilization at 100% RR followed by 75% RR + algae extract at 3ml/l, during the two seasons.

Keywords: *Calendula officinalis*, planting date, nitrogen, algae extract, growth, flowering, chlorophyll

INTRODUCTION

Calendula (*Calendula officinalis* L.), also referred to as pot marigold, is a frequently grown seasonal flower. It blooms for a long time and produces big, multi-petaled, solitary or double flowers that are yellow or orange (Rigane *et al.,* 2013). In addition to being grown for its aesthetic value, pot marigold is used medicinally for its ability to lower blood sugar, reduce inflammation and refine blood (Mohammad and Kashani, 2012). It provides calming benefits for skin conditions like eczema and irritation. The vibrantly colored petals are used sparingly in salads as a greenish color. Its components include alcohol, pentacyclic acid, flavonoids, carotenoids (calenduline, lycopene and carotene) and triterpenes (Samoon *et al*., 2018).

Numerous elements influence the success of every crop's cultivation. One of the crucial elements of the production system for many crops is the date of sowing. The optimal time for planting or sowing ensures that the plant develops and grows in a way that maximizes agricultural yield and makes economic use of the soils (Islam *et al*., 2010). According to Ghani *et al.* (2011), planting date has a significant impact on plant development as well as the active ingredient in aromatic and medicinal crops. The length of time that fennel plants can absorb the benefits of ideal growing circumstances is increased by earlier sowing (Soleymani and Shahrajabian, 2012). According to Massoud *et al.* (2020), when compared to the other transplanting dates (December 1st and 30th, the feverfew plants transplanted on December 15th had the highest values of the vegetative growth criteria, such as fresh and dry weights, plant height and number of branches, and chemical traits, such as N, P, K, chlorophyll, and carotene contents.

Nitrogen serves as a biological catalyst and is a structural component of the cytoplasm of cells as well as an essential component of proteins, purines, amino acids and pyrimidines. The bulk of enzymes, which are crucial for the metabolism of fat and carbohydrates, require phosphorus as a constituent (Nagmote *et al.*, 2020). Many studies revealed that nitrogen fertilizer enhanced pot marigold growth, flowering yield and chemical constituents (Selim and Abdella, 2004; Szwejkowska and Bielski, 2012; Bielski and Szwejkowska, 2013 and Pirmani *et al*., 2022).

In addition to trace elements, vitamins, amino acids, antibiotics, and micronutrients, the extract of seaweed or algae contains growth-promoting hormones such as gibberellins, auxins, cytokinin, betaine, abscisic acid, polyamines and ethylene, which makes them beneficial for increasing agricultural productivity (Panda *et al*., 2012). Using algal extracts topically on fenugreek plants enhanced plant height, number of branches, number of leaves and dry and fresh plant weights during the vegetative growth stage, according to Tarraf *et al.* (2015). This effect was more pronounced on plants treated with 5 g/l algae extract. Additionally, plants with algal extract had noticeably higher potassium, phosphorus and nitrogen levels.

This study set out to examine the impact of varying planting dates, algal extract, and nitrogen fertilizer rate on the growth, blooming characteristics, and chemical composition of *Calendula officinalis* L. The results of this study will help improve the productivity and growth of pot marigolds growing under sandy soil conditions.

MATERIALS AND METHODS

In order to maximize pot marigold (*Calendula officinalis* L.) growth and flowering productivity, a field experiment was set up at the Experimental Farm of the EL-Quassassin Horticultural Research Station, Ismailia Governorate, Hor. Res. Inst., ARC., Egypt, during two consecutive winter seasons in 2022/2023 and 2023/2024.

Four combination treatments between nitrogen fertilizer and algae extract (algae extract (AE) at 3 ml/l, nitrogen at 100% recommended rate (RR), 50% RR of nitrogen + AE at 3 ml/l, and 75% RR of nitrogen + AE at 3 ml/l) and three planting dates of September 15th, October 1st, and October 15th, during 2022 and 2023 as well as their interaction treatments were tested. The recommended rate of nitrogen fertilizer was 500 kg ammonium sulfate (21% N and 24% sulfur) per feddan.

The Medicinal and Aromatic Plants Research Department, Horticulture Research Institute, Agricultural Research Center, Dokky, Giza, provided the seeds of *Calendula officinalis* L. plants. After 45 days from the sowing dates (seeds sowing in 3 speeding seedling trays at 200 seeds/tray), the seedlings were moved to the experimental location where they were planted in a sandy-field for both seasons. Table (1) displays the mechanical and chemical characteristics of the used soil.

Table 1. Physical and chemical characteristics of the used experimental farm soil (average of 2022/2023 and 2023/2024 seasons).

Physical analysis												
Clay (%)		Silt (%)				Sand (%)			Soil texture			
First season (2022/2023)												
21.74		10.58				67.68			Sandy			
Second season (2023/2024)												
21.71		10.53				67.76			Sandy			
Chemical analysis												
pH	E.C. (dSm^{-1})	Soluble cations (mq/l)					Soluble anions (mq./l)			Available (ppm)		
		Ca^{++}	Mg^{++}	Na^{+}	Zn^{++}	Mo^{++}	Cl^{-}	HCO_3^{-}	SO_4^{--}	N	P	K
First season (2022/2023)												
7.79	1.45	1.79	0.96	0.37	1.15	1.22	3.06	1.18	0.78	131	37	58
Second season (2023/2024)												
7.77	1.46	1.78	0.94	0.38	1.13	1.25	3.03	1.17	0.79	129	39	55

This experiment was set up as a split-plot with three replicates. The main plots were designated for planting dates, while the sub plots received treatments of algae or/and nitrogen fertilizer. There were 12 interaction treatments between the main and the sub plots.

The experimental unite area was 5.00 × 3.20 m (16 m^2) and included four rows. The distance between rows was 80 cm and the distance between plants was 30. The seedlings (about 10 cm in height and have 5 or 6 leaves) were planted at different dates as one transplanting per hill.

All pot marigold plants were fertilized with phosphorus and sulfur fertilizers at the rate of 400 kg/feddan of calcium super phosphate (15.5% P_2O_5) and agriculture sulfur at 100 kg/feddan during soil preparation as a soil dressing application. The different nitrogen fertilizer rates (100, 75 and 50% of RR) as ammonium sulfate (21% N) were divided into five equal portions one month after the planting date, before flowering (January 29th, February 10th and February 18th) then three times after every two flowers collection). Potassium fertilizer was added in two equal portions, first with the first nitrogen fertilizer time and the second was added as soil dressing at February 10th.

At the Algal Biotechnology Unit, NRC, Egypt, continuous cultures of the blue-green alga (*Spirulina platensis*), a member of the *Cyanophyta*, were generated in large quantities. The process of making algae extract was first detailed by Enan *et al.* (2016). Chapman and Part (1978) stated that a chemical analysis was performed on an algae extract. Table (2) provides a chemical analysis of the macro- and micronutrients that are now available. Additionally, the AOAC (2012) was used to assess the amino acids content (Table, 2). Using High Performance Liquid Chromatography (HPLC), LC-10AD, the hormones (Table, 2) indole acetic acid, indole butyric acid, and gibberellic acid were quantified. The algae extracts were sprayed at 3 ml/l five times per season (one month after planting date and every 15 days).

Recorded Data:

Growth traits:

After 90 days from the planting date of every treatment, plant height (cm) and branch number per plant as well as fresh and dry weights of herb per pot marigold plant were recorded.

Chemical constituents:

After 90 days from the planting date of every treatment, *β*-carotene (mg/plant) in flower as described by Kishimoto *et al.* (2005), chlorophyll a and b contents in leaves (mg/g as fresh weight) as reported by Wettstein (1957) and N, P and K percentages as indicated by AOAC (2012) were determined.

Flowering measurements:

In the 4th cut of flowers, number of flowers/plant and flower diameter (cm) were

Table 2. Macro and micro nutrients, amino acids and hormones values of algae extract.

The macro- and micronutrients that are present in the utilized algae extract										
Macro-nutrients (%)						Micro-nutrients (%)				Total protein (%)
N	P	K	Na	Ca	Mg	Fe	Cu	Zn	Mn	
13.34	2.32	2.43	0.06	0.43	0.24	1944	17	23	71	19.06

Content of amino acids in the utilized algae extract (%)			
Aspartic (ASP)	1.77	**Histidine (HIS)**	0.24
Isoleucine	0.81	**Glycine (Gly)**	1.07
Threonine (THR)	0.73	**Lysine (LYS)**	0.70
Leucine (LEU)	1.31	**Arginine (ARG)**	0.98
Serine (SER)	0.74	**Alanine (ALA)**	1.55
Tyrosine (TYR)	0.63	**Valine (VAL)**	1.11
Glutamic (GLU)	2.54	**Cysteine (CYC)**	0.22
Phenylalanine (PHE)	0.91	**Methionine (MET)**	0.33
Proline (PRO)	0.67	**Total amino acids**	15.89

HPLC chromatogram of the sample's algal extract hormones		
Gibberellic acid (mg/g)	Indole acetic acid (mg/g)	Indole butyric acid (mg/g)
1.1917	13.662	3.248

determined. The flowers were harvested as 8 cuts every week starting (March 1st) to determine the fresh and dry weights of flowers (g)/plant. The fresh and dry yield of flowers (ton)/feddan/season were determined by calculating the yield of flowers (g)/plant during 8 cuts, concerning the percentage of plants number in feddan in different growing dates.

Statistical Analysis:

The obtained data were examined in accordance with Gomez and Gomez (1984). Using the least significant difference (L.S.D.) means were distinguished at the 5% and 1% probability levels. The Statistics version 9 computer application (Analytical software, 2008) was used to compare the means.

RESULTS AND DISCUSSION

Growth traits:

Results recorded in Tables (3 and 4) show that early planting date gave the highest values of plant height (50.6 and 49.7 cm), number of branches per plant (16.8 and 15.9 branches/plant), herb fresh weight (473.1 and 474.9 g/plant) and herb dry weight (100.3 and 99.3 g/plant) compared to the other planting dates under study during 2022/2023 and 2023/ 2024 seasons. Fertilizing pot marigold plants with 100% RR of nitrogen followed by 75% RR of nitrogen + algae extract at 3 ml/l recorded the highest values of *Calendula officinalis* growth traits with non-significant differences between them, and have significant differences compared with the other rates under study. Furthermore, the best interaction treatment was 100% RR of nitrogen fertilizer alone or 75% RR of nitrogen + 3 ml/l AE interacted with September 15th planting date with non-significant differences between them, and had significant differences compared with the other interaction treatments in both seasons.

The early planted pot marigold plants had a longer period for vegetative growth, which generated taller plants, more branches, and the heaviest fresh and dry herbs. This could be the probable source of the variations in plant growth resulting from planting dates. Moreover, plant height of pot marigolds and dry matter were similarly reduced with delaying sowing date due to a shorter vegetative development period (Moghaddam *et al*., 2015). In addition, according to Ali *et al.* (2020), roselle planted on April 15th produced plants that were taller, had more branches and leaves, and had a higher leaf dry weight per plant than plants planted after later dates.

Table 3. Effect of the interaction between planting dates and algae extract plus nitrogen rates on plant height and number of branches/plant in *Calendula officinalis* L. plant during the two seasons of 2022/2023 and 2023/2024.

Planting dates (A)	N + algae extracts (B)									
	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)
	1st season					2nd season				
	Plant height (cm)									
15th September	43.7	56.3	46.0	56.3	50.6	42.3	55.3	46.0	55.0	49.7
1st October	42.0	53.0	43.7	53.0	47.9	40.7	52.0	42.3	51.7	46.7
15th October	42.3	52.0	40.7	51.3	46.6	39.0	49.3	39.3	49.3	44.3
Mean (B)	42.7	53.8	43.4	53.6		40.7	52.2	42.6	52.0	
	A		B		AB	A		B		AB
LSD at 5%	2.10		1.91		3.31	1.19		1.11		1.92
LSD at 1%	3.18		2.63		4.56	1.80		1.52		2.64
	Number of branches/plant									
15th September	12.3	19.7	15.7	19.3	16.8	12.3	18.3	14.7	18.3	15.9
1st October	11.7	17.7	14.7	17.7	15.4	11.3	17.7	14.7	17.7	15.3
15th October	11.3	16.7	14.3	16.3	14.7	11.3	16.7	14.7	16.3	14.8
Mean (B)	11.8	18.0	14.9	17.8		11.7	17.6	14.7	17.4	
	A		B		AB	A		B		AB
LSD at 5%	0.66		1.16		2.01	NS		0.91		1.57
LSD at 1%	1.00		1.59		2.76	NS		1.25		2.17

Table 4. Effect of the interaction between planting dates and algae extract plus nitrogen rates on fresh and dry weights of herb in *Calendula officinalis* L. plant during the two seasons of 2022/2023 and 2023/2024.

Planting dates (A)	N + algae extracts (B)									
	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)
	1st season					2nd season				
	Fresh weight of herb/plant (g)									
15th September	330.3	533.0	497.3	531.7	473.1	329.0	539.0	493.0	538.7	474.9
1st October	324.3	507.3	408.7	506.0	436.6	321.7	516.0	403.0	515.0	438.9
15th October	316.7	498.0	395.0	499.7	427.3	313.0	492.0	393.7	491.3	422.5
Mean (B)	323.8	512.8	433.7	512.4		321.2	515.7	429.9	515.0	
	A		B		AB	A		B		AB
LSD at 5%	5.95		6.14		10.63	4.04		2.79		4.84
LSD at 1%	9.00		8.44		14.62	6.11		3.84		6.66
	Dry weight of herb/plant (g)									
15th September	75.2	111.3	104.2	110.3	100.3	68.5	112.7	103.0	113.1	99.3
1st October	68.5	107.1	85.7	106.5	92.0	68.1	108.4	85.0	108.2	92.4
15th October	66.9	105.2	83.0	105.1	90.0	66.3	103.7	83.0	103.9	89.2
Mean (B)	70.2	107.9	91.0	107.3		67.6	108.2	90.3	108.4	
	A		B		AB	A		B		AB
LSD at 5%	3.58		3.40		5.89	0.84		0.89		1.54
LSD at 1%	5.42		4.68		8.11	1.28		1.22		2.12

A sufficient amount of nitrogen can increase plant height and branch number by promoting meristem cell division and turgidity. Moosavi *et al*. (2014) demonstrated that a nitrogen and water deficit decreased marigold growth. Likewise, according to Uyi *et al.* (2016), *Chromolaena odorata* plants with high and medium fertilization nitrogen concentrations had considerably longer leaves, taller shoots, and higher above-ground biomass than those with low fertilizations. Also, Kizil *et al.* (2024) showed that fresh and dry herb of *Datura stramonium* gradually increased with elevation nitrogen rates.

Chemical constituents:

As shown in Tables (5 and 6), it is clear that planting date insignificantly affected *β*-carotene content in flowers and nitrogen percentage in leaves in both seasons as well as potassium percentage in the first season only. In addition, the highest values of chlorophyll a and b contents and phosphorus percentage were noticed when pot marigold seedlings were planted at early date (September 15th) in comparison with the other two planting dates. The highest values in chemical constituents of *Calendula officinalis* (*β*-carotene, chlorophyll a and b contents as well as N, P and K percentages) were produced from plants fertilized with 100% RR of nitrogen, followed by 75% RR of nitrogen + 3 ml /l AE with significant differences with the other fertilization types under study in the two tested seasons. Generally, planting pot marigold plants on September 15th and fertilized with 100% RR of nitrogen, followed by 75% RR of nitrogen + 3 ml /l AE produced the highest values of chemical constituents of leaves and flowers

Table 5. Effect of the interaction between planting dates and algae extract plus nitrogen rates on *β*-carotene, chlorophyll a and chlorophyll b contents in *Calendula officinalis* L. plant during the two seasons of 2022/2023 and 2023/2024.

Planting dates (A)	N + algae extracts (B)									
	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)
	1st season					2nd season				
	β-carotene in flower (mg/plant)									
15th September	251.7	262.7	254.3	257.7	256.6	251.7	264.3	255.7	258.7	257.6
1st October	251.7	259.7	254.3	257.7	255.8	253.3	261.7	256.3	259.3	257.7
15th October	251.3	257.0	253.7	257.7	254.9	253.3	260.7	256.7	258.3	257.3
Mean (B)	251.6	259.8	254.1	257.7		252.5	262.2	256.2	258.8	
	A		B		AB	A		B		AB
LSD at 5%	NS		2.24		3.87	NS		1.79		3.11
LSD at 1%	NS		3.08		5.33	NS		2.47		4.28
	Chlorophyll a (mg/g f.w.)									
15th September	0.390	0.477	0.419	0.468	0.438	0.393	0.472	0.427	0.469	0.441
1st October	0.376	0.470	0.409	0.462	0.429	0.377	0.464	0.422	0.466	0.432
15th October	0.360	0.469	0.413	0.456	0.424	0.370	0.467	0.428	0.461	0.432
Mean (B)	0.375	0.472	0.414	0.462		0.380	0.468	0.426	0.466	
	A		B		AB	A		B		AB
LSD at 5%	0.002		0.005		0.008	0.002		0.004		0.006
LSD at 1%	0.003		0.006		0.011	0.003		0.005		0.008
	Chlorophyll b (mg/g f.w.)									
15th September	0.178	0.234	0.209	0.226	0.212	0.179	0.239	0.209	0.227	0.213
1st October	0.169	0.231	0.206	0.223	0.207	0.176	0.235	0.214	0.225	0.212
15th October	0.169	0.231	0.202	0.224	0.206	0.176	0.233	0.208	0.222	0.210
Mean (B)	0.172	0.232	0.206	0.224		0.177	0.235	0.210	0.225	
	A		B		AB	A		B		AB
LSD at 5%	0.002		0.004		0.006	0.002		0.004		0.006
LSD at 1%	0.004		0.005		0.008	0.003		0.005		0.009

Table 6. Effect of the interaction between planting dates and algae extract plus nitrogen rates on nitrogen, phosphorus and potassium percentages in *Calendula officinalis* L. plant during the two seasons of 2022/2023 and 2023/2024.

Planting dates (A)	N + algae extracts (B)									
	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)
	1st season					2nd season				
	Nitrogen (%)									
15th September	1.75	2.37	2.11	2.27	2.12	1.77	2.38	2.15	2.32	2.15
1st October	1.77	2.30	2.16	2.29	2.13	1.85	2.37	2.11	2.32	2.16
15th October	1.76	2.33	2.08	2.29	2.12	1.84	2.30	2.14	2.31	2.15
Mean (B)	1.76	2.33	2.12	2.28		1.82	2.35	2.13	2.32	
	A		B		AB	A		B		AB
LSD at 5%	NS		0.06		0.10	NS		0.05		0.08
LSD at 1%	NS		0.08		0.13	NS		0.06		0.11
	Phosphorus (%)									
15th September	0.383	0.487	0.436	0.469	0.444	0.384	0.497	0.442	0.471	0.448
1st October	0.374	0.481	0.432	0.467	0.438	0.375	0.485	0.419	0.468	0.437
15th October	0.366	0.476	0.428	0.461	0.433	0.371	0.469	0.434	0.466	0.435
Mean (B)	0.374	0.481	0.432	0.465		0.377	0.484	0.432	0.468	
	A		B		AB	A		B		AB
LSD at 5%	0.003		0.005		0.009	0.005		0.007		0.013
LSD at 1%	0.005		0.007		0.013	0.008		0.010		0.018
	Potassium (%)									
15th September	1.79	2.60	2.28	2.46	2.28	1.84	2.67	2.35	2.60	2.37
1st October	1.72	2.60	2.26	2.47	2.26	1.77	2.64	2.31	2.55	2.32
15th October	1.70	2.61	2.26	2.48	2.26	1.73	2.53	2.27	2.48	2.25
Mean (B)	1.74	2.60	2.27	2.47		1.78	2.61	2.31	2.54	
	A		B		AB	A		B		AB
LSD at 5%	NS		0.08		0.13	0.03		0.05		0.08
LSD at 1%	NS		0.10		0.18	0.04		0.06		0.11

compared to the other interaction treatments under study in both seasons.

In the same line, Hashem (2016) revealed that sowing dates and foliar fertilization had significant influences on total chlorophylls/plant and carotenoids contents (mg/g f.w.) in flowers/plant in pot marigold flowers. Because they function as plant growth stimulants and increase the production of carbohydrates and chlorophyll, algae extract liquid fertilizers applied topically can help increase agricultural productivity (Sary *et al*., 2020).

Flowering measurements:

Data listed in Table (7) showed that planting pot marigold on September 15th or October 1st led to a significant increase in number of flowers per plant and flower diameter compared to the delayed planting date (15th October) in the two consecutive seasons. Regarding the fertilization effect, using 100% RR of nitrogen or 75% RR of nitrogen + algae extract at 3 ml/l gave the highest values in this concern. Moreover, the best interaction treatments were 100% RR of nitrogen fertilizer alone followed by 75% RR of nitrogen + 3 ml/l algae extract both interacted with September 15th planting date and the interaction treatment of 50% RR of nitrogen + 3 ml/l algae extract with 1st October planting date, compared with the other interaction treatments in the two tested seasons.

Moreover, fresh and dry weights of flowers per plant in the eighth cuts were significantly increased under earliness planting (September 15th) compared to the other planting dates under study in both seasons (Tables, 8 and 9). Using the highest rate of nitrogen only (100% RR of nitrogen

Table 7. Effect of the interaction between planting dates and algae extract plus nitrogen rates on number of flowers/plant and flower diameter/plant in *Calendula officinalis* L. plant during the two seasons of 2022/2023 and 2023/2024.

Planting dates (A)	N + algae extracts (B)									
	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)
	1st season					2nd season				
	Number of flowers/plant									
15th September	10.3	14.3	11.3	14.0	12.5	11.7	15.7	12.0	14.7	13.5
1st October	9.7	13.3	11.3	12.3	11.7	10.0	14.7	11.3	12.3	12.1
15th October	8.7	12.0	9.0	11.3	10.3	9.7	13.0	10.7	12.0	11.3
Mean (B)	9.6	13.2	10.6	12.6		10.4	14.4	11.3	13.0	
	A		B		AB	A		B		AB
LSD at 5%	0.81		0.73		1.27	0.46		0.96		1.67
LSD at 1%	1.23		1.01		1.74	0.70		1.32		2.29
	Flower diameter (cm)/plant									
15th September	6.21	7.05	6.41	7.02	6.67	6.18	7.04	6.36	6.96	6.64
1st October	6.12	6.94	6.25	6.94	6.56	6.16	6.99	6.30	6.88	6.58
15th October	6.39	6.87	6.20	6.89	6.59	6.11	6.94	6.26	6.87	6.54
Mean (B)	6.24	6.96	6.29	6.95		6.15	6.99	6.31	6.90	
	A		B		AB	A		B		AB
LSD at 5%	NS		0.18		0.31	0.03		0.05		0.09
LSD at 1%	NS		0.24		0.42	0.04		0.07		0.13

Table 8. Effect of planting dates on fresh weight of *Calendula officinalis* L. flowers during eight cuts in the two seasons of 2022/2023 and 2023/2024.

Planting dates	Fresh weight of flowers (g)/plant							
	1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut
	1st season							
15th September	37.7	42.6	49.8	55.4	54.9	44.9	36.0	27.9
1st October	34.7	38.8	47.8	53.8	52.6	45.3	32.9	24.7
15th October	32.1	35.7	44.8	51.8	49.9	42.3	29.1	22.0
LSD at 5%	1.58	1.05	0.36	0.37	0.64	NS	0.73	0.78
LSD at 1%	2.69	1.60	0.55	0.56	0.97	NS	1.10	1.18
	2nd season							
15th September	38.2	42.3	50.8	56.8	55.6	48.8	36.0	27.9
1st October	34.6	37.2	47.4	54.4	52.8	46.5	34.0	25.7
15th October	32.4	35.4	46.1	52.5	49.9	42.8	31.8	23.8
LSD at 5%	3.08	0.83	1.56	1.00	0.79	1.98	1.77	0.36
LSD at 1%	4.66	1.25	2.36	1.51	1.20	3.00	2.68	0.55

Table 9. Effect of planting dates on dry weight of *Calendula officinalis* L. flowers during eight cuts in the two seasons of 2022/2023 and 2023/2024.

Planting dates	Dry weight of flowers (g)/plant							
	1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut
				1st season				
15th September	4.26	4.69	5.11	5.77	5.51	4.34	3.75	3.08
1st October	4.27	4.20	4.95	5.59	5.28	4.04	3.44	2.89
15th October	3.78	4.01	4.67	5.36	4.88	3.83	3.20	2.59
LSD at 5%	0.26	0.21	0.07	0.23	0.09	0.12	0.07	0.13
LSD at 1%	0.39	0.32	0.11	0.34	0.14	0.19	0.10	0.19
				2nd season				
15th September	4.73	4.86	5.45	6.01	5.58	4.63	4.00	3.24
1st October	4.39	4.71	5.17	5.88	5.43	4.28	3.68	3.03
15th October	4.15	4.53	4.83	5.48	5.07	4.14	3.47	3.03
LSD at 5%	0.11	0.25	0.13	0.17	0.26	0.07	0.09	0.12
LSD at 1%	0.17	0.38	0.20	0.11	0.40	0.10	0.14	0.19

fertilizer) followed by 75% RR of nitrogen fertilizer + 3 ml /l algae extract produced the highest values of fresh and dry weights of flower per plant through all cuts with high significant difference with the other fertilization types under study in the two seasons (Tables, 10 and 11). In addition, interacted 100% RR of nitrogen fertilizer or 75% RR of nitrogen fertilizer + 3 ml /l algae extract with September 15th gave the highest values in fresh and dry weights of *Calendula officinalis* flowers in 8th cuts compared to the other interactions through both seasons (Tables, 12 and 13).

The highest values of fresh flowers yield per plant per season (349.3 and 356.3 g/plant) and dry flowers yield per plant per season (36.5 and 38.5 g/plant) were achieved when pot marigold plants were planted on September 15th compared to the other dates under study (Tables, 14 and 15). Using nitrogen fertilizer only at 100% RR followed by 75% RR of nitrogen fertilizer + 3 ml /l algae extract gave the highest values for flower yield per plant with high significant differences with the other fertilizer types under study. Again, the best interaction treatment for fresh and dry flower yield per plant was 100% RR of nitrogen fertilizer alone or 75% RR of nitrogen + 3 ml/l AE interacted with September 15th planting date compared with the other interaction treatments in both seasons.

The number of flower heads per plant was significantly impacted by nitrogen fertilizer, although there was no discernible variation in the diameter of the tubular and ligulate flowers in the *Calendula officinalis* flower head. When 80 kg N/ha was applied, the raw material yield was observed to rise considerably in comparison to the control treatment (Król, 2011). According to Shahrbabaki *et al.* (2013), number of seeds in a head, flower harvest index, flower fresh weight/plant, flower fresh weight yield/hectare, and flower dry weight were all significantly impacted by the interaction between nitrogen fertilizer at 150 kg/hectare and the autumn sowing date of September 15th. Also, Rahmani *et al.* (2014), reported that the third sowing date (June 6th) produced the highest fresh and dry flowers production per hectare as well as the essential yield of *Calendula officinalis*. Furthermore, Singh *et al*. (2016) pointed out that nitrogen application (120 kg/ hectare) significantly stimulated fresh and dry weights of shoot and rhizome of *Zingiber officinale*.

Table 10. Effect of planting dates on fresh weight of *Calendula officinalis* L. flowers during eight cuts in the two seasons of 2022/2023 and 2023/2024.

N + algae extracts	Fresh weight of flowers (g)/plant							
	1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut
				1st season				
Algae ext. 3 ml/l	24.3	26.8	33.8	39.8	38.3	36.3	23.8	13.6
100% N	41.1	45.9	55.8	63.0	61.7	50.4	38.1	32.8
50% N + algae ext. 3 ml/l	32.8	38.1	45.4	50.1	49.9	40.0	31.7	22.2
75% N + algae ext. 3 ml/l	41.0	45.2	54.9	61.8	60.0	49.8	37.1	30.9
LSD at 5%	1.77	2.89	0.96	1.49	2.03	2.20	1.37	2.14
LSD at 1%	2.44	3.98	1.32	2.05	2.8	3.03	1.88	2.95
				2nd season				
Algae ext. 3 ml/l	25.4	28.2	36.4	41.6	40.1	39.3	24.6	14.1
100% N	41.8	42.7	55.3	62.2	61.2	51.0	40.2	33.6
50% N + algae ext. 3 ml/l	32.3	40.2	46.2	52.4	49.7	44.6	31.4	22.9
75% N + algae ext. 3 ml/l	40.7	42.0	54.4	62.0	60.1	49.3	39.4	32.6
LSD at 5%	1.60	2.04	1.38	1.20	2.20	1.14	2.16	1.42
LSD at 1%	2.20	2.81	1.90	1.66	3.03	1.56	2.97	1.95

Table 11. Effect of planting dates on dry weight of *Calendula officinalis* L. flowers during eight cuts in the two seasons of 2022/2023 and 2023/2024.

N + algae extracts	Dry weight of flowers (g)/plant							
	1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut
				1st season				
Algae ext. 3 ml/l	3.01	2.97	3.21	3.74	3.66	2.99	2.58	1.77
100% N	4.81	5.27	5.90	6.66	6.13	4.89	4.17	3.58
50% N + algae ext. 3 ml/l	3.88	3.86	4.80	5.41	5.17	3.64	3.07	2.68
75% N + algae ext. 3 ml/l	4.71	5.11	5.72	6.48	5.93	4.76	4.04	3.40
LSD at 5%	0.35	0.27	0.22	0.18	0.24	0.27	0.15	0.11
LSD at 1%	0.48	0.37	0.30	0.25	0.33	0.37	0.20	0.15
				2nd season				
Algae ext. 3 ml/l	3.39	3.22	3.61	4.27	3.79	3.09	2.86	1.89
100% N	5.09	5.62	6.03	6.76	6.21	5.18	4.33	3.87
50% N + algae ext. 3 ml/l	4.21	4.48	5.08	5.63	5.37	4.17	3.41	2.90
75% N + algae ext. 3 ml/l	5.00	5.48	5.88	6.51	6.07	4.97	4.26	3.74
LSD at 5%	0.35	0.41	0.16	0.13	0.21	0.16	0.12	0.10
LSD at 1%	0.48	0.57	0.23	0.18	0.28	0.22	0.17	0.13

Table 12. Effect of the interaction between planting dates and algae extract plus nitrogen percentages on fresh weight of *Calendula officinalis* L. flowers during eight cuts in the two seasons of 2022/2023 and 2023/2024.

Planting dates	N + algae extracts	Fresh weight of flowers (g)/plant							
		1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut
					1st season				
15th September	Algae ext. 3 ml/l	26.0	29.7	36.3	41.7	41.0	37.7	27.0	15.7
	100% N	44.7	49.3	58.0	64.7	63.0	51.0	41.3	35.7
	50% N + algae ext. 3 ml/l	35.7	42.3	48.0	51.7	53.3	40.7	35.3	25.3
	75% N + algae ext. 3 ml/l	44.3	49.0	57.0	63.7	62.3	50.3	40.3	35.0
1st October	Algae ext. 3 ml/l	25.0	26.3	33.7	39.7	38.0	36.3	23.7	13.7
	100% N	40.7	47.7	56.3	63.0	62.3	52.0	38.7	33.3
	50% N + algae ext. 3 ml/l	32.7	34.3	46.0	50.3	50.0	41.3	31.0	21.7
	75% N + algae ext. 3 ml/l	40.3	46.7	55.3	62.0	60.0	51.3	38.3	30.0
15th October	Algae ext. 3 ml/l	22.0	24.3	31.3	38.0	36.0	35.0	20.7	11.3
	100% N	38.0	40.7	53.0	61.3	59.7	48.3	34.3	29.3
	50% N + algae ext. 3 ml/l	30.0	37.7	42.3	48.3	46.3	38.0	28.7	19.7
	75% N + algae ext. 3 ml/l	38.3	40.0	52.3	59.7	57.7	47.7	32.7	27.7
	LSD at 5%	3.07	5.01	1.66	2.58	3.52	3.82	2.37	3.71
	LSD at 1%	4.22	6.90	2.28	3.55	4.85	5.25	3.26	5.11
					2nd season				
15th September	Algae ext. 3 ml/l	26.3	32.0	39.7	44.3	42.3	41.0	26.0	16.3
	100% N	46.0	46.7	57.7	64.7	63.7	54.7	42.3	35.7
	50% N + algae ext. 3 ml/l	35.3	44.0	49.0	53.3	53.7	46.3	34.7	24.7
	75% N + algae ext. 3 ml/l	45.0	46.3	57.0	64.7	62.7	53.3	41.0	35.0
1st October	Algae ext. 3 ml/l	26.0	27.7	34.7	39.3	39.3	40.3	24.7	14.3
	100% N	41.0	41.7	55.0	62.3	61.3	50.7	42.0	33.3
	50% N + algae ext. 3 ml/l	32.0	38.3	46.7	54.0	50.3	45.0	30.3	22.3
	75% N + algae ext. 3 ml/l	39.3	41.0	53.3	62.0	60.3	50.0	39.0	32.7
15th October	Algae ext. 3 ml/l	24.0	25.0	35.0	41.0	38.7	36.7	23.0	11.7
	100% N	38.3	39.7	53.3	59.7	58.7	47.7	36.3	31.7
	50% N + algae ext. 3 ml/l	29.7	38.3	43.0	50.0	45.0	42.3	29.3	21.7
	75% N + algae ext. 3 ml/l	37.7	38.7	53.0	59.3	57.3	44.7	38.3	30.0
	LSD at 5%	2.77	3.53	2.39	2.09	3.81	1.97	3.74	2.45
	LSD at 1%	3.81	4.86	3.29	2.87	5.24	2.71	5.15	3.38

Table 13. Effect of the interaction between planting dates and algae extract plus nitrogen percentages on dry weight of *Calendula officinalis* L. flowers during eight cuts in the two seasons of 2022/2023 and 2023/2024.

Planting dates	N + algae extracts	Dry weight of flowers (g)/plant							
		1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut
		1st season							
15th September	Algae ext. 3 ml/l	2.93	3.20	3.47	4.10	3.90	3.07	2.77	2.00
	100% N	5.33	5.77	6.03	6.73	6.40	5.23	4.47	3.83
	50% N + algae ext. 3 ml/l	3.53	4.10	5.03	5.73	5.43	4.03	3.40	2.87
	75% N + algae ext. 3 ml/l	5.23	5.70	5.90	6.50	6.30	5.03	4.36	3.63
1st October	Algae ext. 3 ml/l	3.20	2.93	3.33	3.70	3.57	3.03	2.53	1.73
	100% N	4.80	5.07	5.93	6.70	6.23	4.70	4.17	3.60
	50% N + algae ext. 3 ml/l	4.37	3.90	4.80	5.43	5.27	3.67	3.00	2.77
	75% N + algae ext. 3 ml/l	4.70	4.90	5.73	6.53	6.07	4.77	4.07	3.47
15th October	Algae ext. 3 ml/l	2.90	2.77	2.83	3.43	3.50	2.87	2.43	1.57
	100% N	4.30	4.97	5.73	6.53	5.77	4.73	3.87	3.30
	50% N + algae ext. 3 ml/l	3.73	3.57	4.57	5.07	4.80	3.23	2.80	2.40
	75% N + algae ext. 3 ml/l	4.20	4.73	5.53	6.40	5.43	4.47	3.70	3.10
	LSD at 5%	0.60	0.46	0.38	0.32	0.41	0.47	0.26	0.19
	LSD at 1%	0.83	0.63	0.52	0.44	0.57	0.64	0.35	0.27
		2nd season							
15th September	Algae ext. 3 ml/l	3.50	3.30	3.83	4.30	3.97	3.10	3.17	2.13
	100% N	5.63	5.97	6.33	7.00	6.40	5.53	4.60	4.00
	50% N + algae ext. 3 ml/l	4.20	4.47	5.53	6.03	5.63	4.60	3.77	3.00
	75% N + algae ext. 3 ml/l	5.57	5.70	6.10	6.70	6.33	5.27	4.47	3.83
1st October	Algae ext. 3 ml/l	3.37	3.17	3.70	4.67	3.87	3.10	2.80	1.77
	100% N	5.00	5.57	6.03	6.80	6.27	5.03	4.30	3.77
	50% N + algae ext. 3 ml/l	4.33	4.67	5.00	5.53	5.43	4.23	3.33	2.93
	75% N + algae ext. 3 ml/l	4.87	5.43	5.93	6.53	6.13	4.77	4.27	3.63
15th October	Algae ext. 3 ml/l	3.30	3.20	3.30	3.83	3.53	3.07	2.60	1.77
	100% N	4.63	5.33	5.73	6.47	5.97	4.97	4.10	3.83
	50% N + algae ext. 3 ml/l	4.10	4.30	4.70	5.33	5.03	3.67	3.13	2.77
	75% N + algae ext. 3 ml/l	4.57	5.30	5.60	6.30	5.73	4.87	4.03	3.77
	LSD at 5%	0.60	0.72	0.28	0.23	0.36	0.28	0.21	0.17
	LSD at 1%	0.83	0.98	0.39	0.32	0.49	0.38	0.29	0.23

Table 14. Effect of the interaction between planting dates and algae extract plus nitrogen rates on fresh weight yield of flowers/plant/season and fresh weight yield of flowers/fed/season in *Calendula officinalis* L. plant during the two seasons of 2022/2023 and 2023/2024.

Planting dates (A)	N + algae extracts (B)									
	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)
	1st season					2nd season				
	Fresh weight yield of flowers (g/plant/season)									
15th September	255.0	407.7	332.3	402.0	349.3	268.0	411.3	341.0	405.0	356.3
1st October	236.3	394.0	307.3	384.0	330.4	246.3	387.3	319.0	377.7	332.6
15th October	218.7	364.7	291.0	356.0	307.6	235.0	365.3	299.3	359.0	314.7
Mean (B)	236.7	388.8	310.2	380.7		249.8	388.0	319.8	380.6	
	A		B		AB	A		B		AB
LSD at 5%	1.76		9.92		17.19	3.11		5.64		9.77
LSD at 1%	2.67		13.66		23.66	4.71		7.76		13.45
	Fresh weight yield of flowers (ton/fed/season)									
15th September	0.503	0.801	0.652	0.793	0.687	0.449	0.691	0.572	0.681	0.598
1st October	4.926	8.215	6.405	8.007	6.888	3.384	8.182	6.738	7.982	6.571
15th October	4.652	7.755	6.187	7.574	6.542	5.120	7.956	6.520	7.821	6.854
Mean (B)	3.360	5.590	4.415	5.458		2.984	5.609	4.610	5.495	
	A		B		AB	A		B		AB
LSD at 5%	0.751		0.231		0.401	0.673		0.979		1.696
LSD at 1%	1.137		0.319		0.552	1.019		1.347		2.334

Table 15. Effect of the interaction between planting dates and algae extract plus nitrogen rates on dry weight yield of flowers/plant/season and dry weight yield of flowers/fed/season in *Calendula officinalis* L. plant during the two seasons of 2022/2023 and 2023/2024.

Planting dates (A)	N + algae extracts (B)									
	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)	Algae ext. 3 ml/l	100% N	50% N + algae ext. 3 ml/l	75% N + algae ext. 3 ml/l	Mean (A)
	1st season					2nd season				
	Dry weight yield of flowers (g/plant/season)									
15th September	25.4	43.8	34.1	42.7	36.5	27.3	45.5	37.2	44.0	38.5
1st October	24.0	41.2	33.2	40.2	34.7	26.4	42.8	35.5	41.6	36.6
15th October	22.3	39.2	30.2	37.6	32.3	24.6	41.0	33.0	40.2	34.7
Mean (B)	23.9	41.4	32.5	40.2		26.1	43.1	35.2	41.9	
	A		B		AB	A		B		AB
LSD at 5%	0.34		1.13		1.96	0.19		0.95		1.65
LSD at 1%	0.51		1.56		2.70	0.28		1.31		2.27
	Dry weight yield of flowers (ton/fed/season)									
15th September	0.050	0.086	0.067	0.084	0.072	0.046	0.077	0.062	0.074	0.065
1st October	0.173	0.858	0.692	0.839	0.641	0.559	0.942	0.750	0.879	0.782
15th October	0.474	0.833	0.642	0.799	0.687	0.536	0.894	0.720	0.876	0.756
Mean (B)	0.232	0.593	0.467	0.574		0.380	0.638	0.511	0.610	
	A		B		AB	A		B		AB
LSD at 5%	0.075		0.094		0.163	0.085		0.023		0.039
LSD at 1%	0.113		0.129		0.224	0.128		0.031		0.054

CONCLUSION

The obtained results indicated that the early planting date of September 15th, in combination with either 100% RR kg of nitrogen fertilizer (105 kg N/feddan) or 75% RR of nitrogen with algal extract at 3 ml/l sprayed five times per season, was recommended. These interaction treatments appeared to be the most promising treatments in terms of future improvement. Our findings on the growth, chemical constituents and flower yield of *Calendula officinalis* under sandy soil conditions may be useful in advising farmers and researchers studying aromatic and medicinal plants in arid and semi-arid regions regarding the management and appropriate application of nitrogenous fertilizers and algae extract under the suitable planting date.

We observed that there were no significant differences between 100% RR kg of nitrogen fertilizer (105 kg N/feddan) and 75% RR of nitrogen with algae extract at 3 ml/L, both combined with October 1st planting date, on the yield of fresh and dry weights of pot marigold flowers per plant and per feddan which showed that, algae extract at 3 ml/L decreased the using of 100% RR kg of nitrogen fertilizer to 75% RR, which in turn, decreased the cost of flowers yield production in sandy soil conditions.

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تأثير ميعاد الزراعة ومستخلص الطحالب ومعدلات الأسمدة النيتروجينية على نمو وإنتاجية الإقحوان تحت ظروف الأراضي الرملية

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أجريت تجربة حقلية بالمزرعة التجريبية بمحطة بحوث البساتين بالقصاصين بمحافظة الإسماعيلية بمصر خلال موسمين شتويين متتاليين لأعوام ٢٠٢٢/٢٠٢٣ و ٢٠٢٣/٢٠٢٤ بهدف تحقيق النمو الأمثل والإنتاجية من الأزهار لنبات الأقحوان. أختبرت ثلاثة مواعيد للزراعة (١٥ سبتمبر و ١ أكتوبر و ١٥ أكتوبر) خلال عامي ٢٠٢٢ و ٢٠٢٣ ، وأربع معاملات تداخل بين النيتروجين ومستخلص الطحالب (مستخلص الطحالب بمعدل ٣ مل/لتر، النيتروجين بمعدل ١٠٠٪ من المعدل الموصي به و ٥٠٪ من المعدل الموصي به من النيتروجين + مستخلص الطحالب و٧٥٪ من المعدل الموصي به من النيتروجين + مستخلص الطحالب) ومعاملات التفاعل بينهما. أشارت النتائج المتحصل عليها إلى أن الزراعة المبكرة في ١٥ سبتمبر تليها الزراعة فى ١ أكتوبر أدت إلى زيادة إرتفاع النبات وعدد الأفرع لكل نبات ووزن العشب الطازج والجاف لكل نبات وعدد الأزهار لكل نبات وقطر الزهرة وكذلك المحتوى من الكلوروفيل أ و ب والنسب المئوية من الفوسفور والبوتاسيوم ووزن الأزهار الطازج والجاف لكل نبات للموسم الواحد مقارنة بموعد الزراعة الثالث قيد الدراسة. أعطى التسميد النيتروجيني بنسبة ١٠٠٪ من المعدل الموصى به متبوعًا بنسبة ٧٥٪ من المعدل الموصى به من التسميد النيتروجيني + ٣ مللي/لتر من مستخلص الطحالب أعلى قيم للصفات المذكورة أعلاه. بشكل عام ، فإن زراعة شتلات الإقحوان خلال ١٥ سبتمبر متبوعاً بموعد الزراعة ١ أكتوبر بالإضافة إلى تسميدها بنسبة ١٠٠٪ من المعدل الموصي به من النيتروجين متبوعًا بنسبة ٧٥٪ من المعدل الموصى به من التسميد النيتروجيني+ رشها بمستخلص الطحالب ٣ مل/لتر خمس مرات في الموسم أدى إلى تحسين النمو وإنتاجية الأزهار والمكونات الكيميائية لنبات الإقحوان تحت ظروف محافظة الإسماعيلية. كما تم الحصول على أعلى محصول طازج وجاف للأزهار/فدان/موسم من معاملة التفاعل (الزراعة في ١ أكتوبر بالإضافة إلى التسميد النيتروجيني بنسبة ١٠٠٪ من المعدل الموصى به تليها ٧٥٪ من المعدل الموصى به + مستخلص الطحالب بمعدل ٣ مل/لتر) ، خلال الموسمين.