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Effect of Planting Dates and Some Growth Stimulants on Growth and Productivity of Chia Plant

Hassan, A.A., Abbas, Eman, G. and Taha, Ragaa, A.

Horticulture Department, Faculty of Agriculture, Minia University, Egypt.

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Corresponding author:
Ahmed Ali Hassan

Email:
Ahmed_hassan@mu.edu.eg

ABSTRACT

A field experiment was carried out during the two consecutive seasons 2021/2022 and 2022/2023 at the Nursery of ornamental plants, Faculty of Agriculture, Minia University. The experiment was arranged in a completely randomized block design in a split plot arrangement with 3 replicates. Main plots including planting dates at 15th Oct., 1st Nov., and 15th Nov., while sub-plots including amino acids at 0, 1, 2 and 3 ml/l and seaweed extract at 1.5, 3 and 4.5 m/l, plus the control. In both seasons, plant height, branches number, herb dry weights, seed yield/plant and /fed. as well as fixed oil productivity and photosynthetic pigments were significantly affected with planting dates and growth stimulant substances applications. Also, there was a significant interaction between both main and sub-plots treatments, except herb dry weight in the first season and number of branches in the second seasons as well as chlorophyll b and carotenoids in both seasons. In general, the best interaction treatments were obtained during plants sown in the first date and sprayed with amino acids at 3 ml/l or seaweed extract at 1.5 ml/l.

KEYWORDS: Chia, planting date, amino acids and seaweed extract

1. INTRODUCTION

Chia (*Salvia hispanica*, L.) is an annual herb native to Southern Mexico, and Northern Guatemala and belongs to the *Lamiaceae* family (Ixtaina *et al*., 2008 and Capitani *et al*., 2012). Chia seeds have a high nutrition value due to their high contents of fat, carbohydrates, dietary fibre, minerals, vitamins, and antioxidants (Reyes-Caudillo *et al*., 2008 and Marineli *et al*., 2015). So that, it has been consider as a part of human food for about 5500 years (Ayerza and Coates, 2011). Due to their hydrophilic properties, they are used in the food industry as an alternate to fat and eggs as a mucilage (Deka and Das, 2017 and Ding *et al*., 2018) which is a rich source of polysaccharides, mainly cellulose, and thus can be used in the production of edible coating films (Muñoz *et al*., 2012 and Segura-Campos *et al*., 2014). In addition to that their great content of phenolic compounds have been scientifically proven to exhibit antioxidative functions (Guevara-Cruz *et al*., 2012).

Planting date is a main factor affecting plant growth and productivity (Abbas *et al*., 2019). That could be due to variations in climatic conditions such as humidity,

photoperiod and temperature, which extremely vary with the seasons (Sacks *et al*., 2010). In other geographical region planting dates exhibited a direct impact on the physiological potential of seed production of chia plant (Goergen *et al*., 2018).

Stimulant substances are products whose properties improve the physiological and metabolic processes of plants (Mariani and Ferrante, 2017). Now a days the trend toward healthy agricultural products has been dramatically increased including using various biostimulant products (Povero *et al*., 2016). One of these products is amino acids (AAs) which are precursors and elements of proteins and other N compounds and can serve in some circumstances as a source of carbon and energy (Davies, 1982). Owing to especial AA structure they have several positive roles in plant development influencing the production of proteins, carbohydrates, enzymes, and gene expression (Rai, 2002 and El-Desouky *et al*., 2022). Seaweed extracts employed as nutrient supplements improving plant growth via a variety of physiological plant responses. Furthermore, they have been shown a significant use to improve plant tolerance to a wide range of abiotic stresses (Khan *et al*., 2009). The physiological response of many crops to SWE application has been extensively reviewed by (Margal *et al*., 2023). The aim of this study was to optimize the chia plants production via detecting the best planting date and applied some plant growth biostimulants.

2. MATERIALS AND METHODS

A complete randomized block design in a split plot arrangement included 3 replicates was carried out during 2021/2022 and 2022/2023 at Ornamental Nursery, Faculty of Agric., Minia Univ. Seeds of chia plants were planted in clayey loamy soil which its physical and chemical properties shown in Table a (Jackson, 1973). The experiment included main plots (A) (8.40 × 3 m /plot) with 60 cm distance between the rows and 40 cm between the hills within the row (7 hills/row). The main plot included three different planting dates; 15th Oct., 1st Nov. and 15th Nov. In all cases seedlings were thinned twice, after 2 and 3 weeks from sowing, finally each hill contained 2 plants (each plot contains 196 plants, equal 32.536 plants per feddan). The sub-plot (B) was foliar spray of AAs at 1, 2, and 3 ml/l, and SWE at 1.5, 3 and 4.5 ml/l in addition to a control treatment which treated with tap water. Therefore, the interaction treatments (A×B) were 21 treatments. Each sub-plot treatment included 2 rows for each treatment.

Table a. Physical and chemical analysis of the experimental soil in both seasons (2021/2022 and 2022/2023).

Soil character	Values		Soil character	Values	
	2021/2022	2022/2023		2021/2022	2022/2023
Physical properties:			**Exchangeable nutrients:**		
Sand (%)	28.59	28.92	**Ca^{++} (mg/100 g)**	31.43	31.45
Silt (%)	30.29	30.66	**K^{+} (mg/100 g)**	2.45	2.46
Clay (%)	41.12	40.42	**Na^{+} (mg/100 g)**	2.46	2.48
Soil type	Clay loam	Clay loam	**Avail. P^{+} (%)**	15.40	15.44
Chemical properties:			**DTPA-Extractable nutrients:**		
pH (1:2.5)	7.79	7.73	**Fe (ppm)**	8.39	8.31
E.C. (dS/m)	1.06	1.04	**Cu (ppm)**	2.04	2.03
O.M.	1.65	1.61	**Zn (ppm)**	2.81	2.91
$CaCO_3$	2.10	2.13	**Mn (ppm)**	8.19	8.14
Total N (`%)	0.08	0.08			

The commercial AAs; AMINOGEN that contains a mixture of free amino acids was obtained from Chema Ind. Com., Cairo, Egypt. However, SWE; Crop+^{TM}Plus was obtained from Cytozyme Lab., Inc. USA. Plants were foliar sprayed three times with AAs or SWE concentrations. The first treatment was commenced after 1 month of planting, then every 3-week intervals.

The three photosynthetic pigments chlorophyll a and b, and carotenoids contents (mg/g FW) were determined using sample of 0.5 g of the fresh leaves three two weeks of the 3rd foliar application according to (Moran, 1982).

The harvest was performed at physiological maturity when about 75% of the plants were completely senescent. That was performed on 15th Apr. for 1st date, on 23rd Apr. for 2nd date, and on 9th May for 3rd date. Plants were cut just above soil surface then plant height, branches number/plant and herb dry weight were estimated. Seeds were separated to estimate seed yield/plant and /fed. Fixed oil productivity (percentage, per plant and per fed.) were determined according to the methods of (AOAC, 2000). The obtained data were tabulated and subjected to proper statistical and analysis according to Mead *et al,* (1993) using the statistical program MSTAT-C (1986) and the L.S.D. test at 5% was followed to compare between the means.

3. RESULTS and DISCUSSION

3.1.Vegetative growth characters

Data listed in Tables (1, 2 and 3) showed that plant height, branches number and herb dry weights/plant of chia plants were significantly affected due to planting dates. The highest values of plant height, branches number and dry weight of herb were obtained from the first planting date (15th Oct.), followed by 2nd date (1st Nov.) and then 3rd date (15th Nov.) which gave the lowest values in both seasons.
Similarly, Karim *et al*. (2016), Goergen *et al*. (2019) and da Silva *et al*. (2020) on chia plant.

Concerning the growth stimulant substances applications (AAs and SWE), it can be concluded that all tested treatments led to significant improvement of plant height, branches number and dry weights of chia compared with check treatment as shown in Tables (1, 2 and 3). The most effective treatment which produced the tallest plants, highest branches number and the heaviest dry weight was the treatment of AAs at 3 ml/l. Similar trend was found in the second growing season.

Table 1. Effect of planting dates and some growth stimulant substances on the plant height (cm) of chia seeds during 2021/2022 and 2022/2023 seasons.

Growth stimulant treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	125.97	116.94	108.85	117.25
AAs 1.0 ml/l	127.11	129.57	121.22	125.97
AAs 2.0 ml/l	130.57	130.74	123.95	128.42
AAs 3.0 ml/l	131.36	132.60	128.71	130.89
SWE 1.5 ml/l	130.99	121.72	112.33	121.68
SWE 3.0 ml/l	127.88	119.86	111.36	119.70
SWE 4.5 ml/l	126.33	117.03	108.96	117.44
Mean (A)	128.60	124.07	116.48	
LSD at 5%	A: 3.33	B: 3.00	AB: 5.19	
Second season (2022/2023)				
Control	121.90	118.76	105.46	115.37
AAs 1.0 ml/l	127.87	123.63	124.25	125.25
AAs 2.0 ml/l	130.40	126.48	130.12	129.00
AAs 3.0 ml/l	131.34	128.39	131.08	130.27
SWE 1.5 ml/l	127.27	126.33	113.35	122.32
SWE 3.0 ml/l	124.81	124.99	112.42	120.74
SWE 4.5 ml/l	123.12	119.55	109.19	117.29
Mean (A)	126.67	124.02	117.98	
LSD at 5%	A: 6.27	B: 3.06	AB: 5.29	

AAs: Amino acids, SWE: Seaweed extract.

Table 2. Effect of planting dates and some growth stimulant substances on the number of branches/plant) of chia seeds during 2021/2022 and 2022/2023 seasons.

Growth stimulant treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	16.5	13.8	11.7	14.0
AAs 1.0 ml/l	18.5	21.2	13.7	17.8
AAs 2.0 ml/l	19.2	19.0	14.6	17.6
AAs 3.0 ml/l	19.7	18.9	16.0	18.2
SWE 1.5 ml/l	18.2	17.4	13.1	16.3
SWE 3.0 ml/l	17.5	16.3	12.4	15.4
SWE 4.5 ml/l	16.7	15.9	11.8	14.8
Mean (A)	18.1	17.5	13.3	
LSD at 5%	A: 0.9	B: 1.1	AB: 2.0	
Second season (2022/2023)				
Control	16.9	15.9	12.0	14.9
AAs 1.0 ml/l	18.2	17.5	15.7	17.2
AAs 2.0 ml/l	20.9	19.2	16.4	18.8
AAs 3.0 ml/l	22.8	21.1	17.1	20.3
SWE 1.5 ml/l	19.4	18.3	14.2	17.3
SWE 3.0 ml/l	18.1	17.6	13.8	16.5
SWE 4.5 ml/l	17.4	16.6	13.2	15.7
Mean (A)	19.1	18.0	14.6	
LSD at 5%	A: 1.3	B: 1.1	AB: NS	

AAs: Amino acids, SWE: Seaweed extract.

Table 3. Effect of planting dates and some growth stimulant substances on the dry weight (g/plant) of chia seeds during 2021/2022 and 2022/2023 seasons.

Growth stimulant treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	50.74	42.12	20.50	37.79
AAs 1.0 ml/l	59.22	54.42	31.64	48.43
AAs 2.0 ml/l	63.02	56.61	38.04	52.56
AAs 3.0 ml/l	74.18	65.05	45.95	61.73
SWE 1.5 ml/l	65.54	62.17	44.56	57.42
SWE 3.0 ml/l	60.33	54.75	36.65	50.58
SWE 4.5 ml/l	55.54	49.44	31.33	45.44
Mean (A)	61.22	54.94	35.53	
LSD at 5%	A: 4.06	B: 3.80	AB: NS	
Second season (2022/2023)				
Control	43.96	43.67	28.98	38.87
AAs 1.0 ml/l	54.45	50.84	36.55	47.28
AAs 2.0 ml/l	59.95	54.87	38.62	51.15
AAs 3.0 ml/l	67.13	62.30	42.88	57.44
SWE 1.5 ml/l	66.83	63.06	37.38	55.76
SWE 3.0 ml/l	64.37	61.34	35.72	53.81
SWE 4.5 ml/l	60.35	56.19	33.24	49.93
Mean (A)	59.58	56.04	36.20	
LSD at 5%	A: 3.93	B: 2.31	AB: 4.00	

AAs: Amino acids, SWE: Seaweed extract.

In agreement withs these results were the findings of El- Sayed *et al*. (2007), Ali and Sallam (2022) on caraway, Mostafa (2015) on fennel, Tarraf *et al*. (2015) on fenugreek and Ayyat *et al*. (2021) on *Nigella sativa* for AAs, as well as, El-Desouky *et al*. (2022) on chia, Tarraf *et al*. (2015), Mafakheri and Asghari (2018) and Dehkordi *et al*. (2021) on fenugreek, Hassan *et al*. (2022) and Ali *et al*. (2023) on fennel in regard to SWE.

The interaction between planting dates and growth stimulant substances applications for plant height, branches number and dry weight was significant in the two experimental seasons, except herb dry weight in the first season and number of branches in the second seasons as shown in Tables (1, 2 and 3). The most effective interaction treatment which produced the tallest plants, highest mean branches number and the heaviest herb dry weight/plant in both seasons was for chia planted on 15th Oct. and sprayed with 3 ml/l of AAs.

3.2. Seed yield /plant and /fed

It is clear from recorded data in Tables (4 and 5) that seed yield/plant and /fed. of chia plants were significantly affected by planting dates in the first and second seasons. In both seasons, the highest seed yields were for chia which planted on the earliest date (15th Oct.). But the lowest ones were for the last planting date (15th Nov.).

The earliest planting date have a positive effect on seed production as pointed out with Karim *et al*. (2016), Baginsky *et al*. (2016) and Rasha *et al*., (2020) on chia.

Regarding the influence of stimulant substances treatments on seed yields (/plant and /fed.) of chia, data shown in Tables (4 and 5) proved that all used treatments significantly promoted the yield of seeds/plant and /fed. comparing with untreated plants in the two experimental seasons. The highest values of seed yield (per plant and per feddan) were recorded from plants received the treatment of SWE at 1.5 ml. Similar trend was obtained in second growing season.

Table 4. Effect of planting dates and some growth stimulant substances on the seed yield/plant (g) of chia seeds during 2021/2022 and 2022/2023 seasons.

Growth stimulant treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	12.72	11.51	5.84	10.02
AAs 1.0 ml/l	13.63	12.72	6.99	11.11
AAs 2.0 ml/l	14.94	13.08	7.39	11.80
AAs 3.0 ml/l	16.03	13.41	8.44	12.63
SWE 1.5 ml/l	20.02	14.11	7.74	13.96
SWE 3.0 ml/l	17.26	13.06	7.58	12.63
SWE 4.5 ml/l	14.94	12.64	7.06	11.55
Mean (A)	15.65	12.93	7.29	
LSD at 5%	A:1.11	B:0.95	AB:1.65	
Second season (2022/2023)				
Control	10.10	9.42	7.14	8.89
AAs 1.0 ml/l	10.70	10.25	8.11	9.69
AAs 2.0 ml/l	13.23	12.18	8.54	11.32
AAs 3.0 ml/l	17.39	15.44	8.97	13.93
SWE 1.5 ml/l	19.74	18.04	10.09	15.96
SWE 3.0 ml/l	17.61	15.58	9.20	14.13
SWE 4.5 ml/l	15.75	14.30	8.83	12.96
Mean (A)	14.93	13.60	8.70	
LSD at 5%	A:0.58	B:0.92	AB:1.60	

AAs: Amino acids, SWE: Seaweed extract.

Table 5. Effect of planting dates and some growth stimulant substances on the seed yield/fed. (kg) of chia seeds during 2021/2022 and 2022/2023 seasons.

Growth stimulant Treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	413.86	374.49	190.01	326.12
AAs 1.0 ml/l	443.47	413.86	227.43	361.58
AAs 2.0 ml/l	486.09	425.57	240.44	384.03
AAs 3.0 ml/l	521.55	436.31	274.60	410.82
SWE 1.5 ml/l	651.37	459.08	251.83	454.09
SWE 3.0 ml/l	561.57	424.92	246.62	411.04
SWE 4.5 ml/l	486.09	411.26	229.70	375.68
Mean (A)	509.14	420.78	237.23	
LSD at 5%	A: 35.44	B: 30.50	AB: 52.83	
Second season (2022/2023)				
Control	328.61	306.49	232.31	289.14
AAs 1.0 ml/l	348.14	333.49	263.87	315.17
AAs 2.0 ml/l	430.45	396.29	277.86	368.20
AAs 3.0 ml/l	565.80	502.36	291.85	453.33
SWE 1.5 ml/l	642.26	586.95	328.29	519.17
SWE 3.0 ml/l	572.96	506.91	299.33	459.73
SWE 4.5 ml/l	512.44	465.26	287.29	421.67
Mean (A)	485.81	442.54	282.97	
LSD at 5%	A: 18.60	B: 29.58	AB: 51.23	

AAs: Amino acids, SWE: Seaweed extract.

In accordance with the obtained results were those of Hendawy and Ezz El-Din (2010) on fennel, Rezakhani and Hadi (2017) and Abd-Allah *et al*. (2021) on coriander and Aly *et al*. (2022) on anise insured our results on AAS, as well as, El-Desouky *et al*. (2022) on chia, Tursun (2022) on coriander and Rahgoshahi *et al*. (2023) on cumin for SWE.

The interaction between main and sub-plots treatments was significant in the two growing seasons for seed yield (/plant and /fed.). In this concern, the highest values of seed yield/plant and /fed. were produced from chia which planted on 15th Oct. and treated with 1.5 ml/l of SWE.

3.3. Fixed oil production

In fact, results showed significant effect of planting date on fixed oil production, [percentage, yield per plant (ml) and per fed. (l)] of chia plant seeds in the 1st and 2nd seasons (Tables 6, 7 and 8). Generally, delaying planting date from middle October to middle November decreased oil% and yields (plant and fed.). So, the highest oil percentage in the seeds (35.90% in the 1st season and 36.10% in the 2nd one), were recorded for plants which were sown on 15th Oct. Planting chia on 15th Nov. had significantly the minimum percentage (27.95 and 33.14%) in the first and second seasons, respectively. The difference among the first and second planting dates was not significantly differed in both seasons. Similarly, Rasha *et al*., (2020) on chia plant and Shamsi *et al*. (2012) on oilseed rape.

In regard to growth stimulant substances applications, all used treatments proved to be effective in augmenting fixed oil% by significant increases over those of control plants in the two growing seasons as clearly shown in (Tables 6, 7 and 8). The lowest oil% in both seasons were recorded for control plants (30.97 and 32.39% respectively). On the other had the highest oil% (35.49 and 37.03%) were for plants treated with the high concentration of SWE (4.5 ml/l). However, the highest values of fixed oil yield per plant and per feddan were achieved with the low level of SWE (1.5 ml/l).

Many investigators explored the beneficial influence of SWE on oil productivity for examples El-Desouky *et al*. (2022) on chia and Sary et al. (2020) on soybean.

Table 6. Effect of planting dates and some growth stimulant substances on fixed oil percentage (%) of chia seeds during 2021/2022 and 2022/2023 seasons.

Growth stimulant Treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	33.78	35.18	23.93	30.97
AAs 1.0 ml/l	34.27	35.67	26.82	32.25
AAs 2.0 ml/l	34.57	35.75	27.98	32.77
AAs 3.0 ml/l	35.53	36.10	27.95	33.19
SWE 1.5 ml/l	36.92	35.33	29.03	33.76
SWE 3.0 ml/l	37.42	35.90	29.23	34.18
SWE 4.5 ml/l	38.78	36.97	30.73	35.49
Mean (A)	35.90	35.84	27.95	
LSD at 5%	A: 0.83	B: 0.50	AB: 1.44	
Second season (2022/2023)				
Control	34.87	33.45	28.87	32.39
AAs 1.0 ml/l	35.77	35.28	31.92	34.32
AAs 2.0 ml/l	35.98	35.90	33.02	34.97
AAs 3.0 ml/l	36.32	36.33	33.48	35.38
SWE 1.5 ml/l	35.45	33.63	34.02	34.37
SWE 3.0 ml/l	35.67	36.83	35.15	35.88
SWE 4.5 ml/l	38.68	36.90	35.52	37.03
Mean (A)	36.10	35.48	33.14	
LSD at 5%	A: 0.83	B: 0.76	AB: 1.31	

AAs: Amino acids, SWE: Seaweed extract.

Table 7. Effect of planting dates and some growth stimulant substances on fixed oil yield/plant (ml) of chia seeds during 2021/2022 and 2022/2023 seasons.

Growth stimulant treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	4.29	4.05	1.40	3.25
AAs 1.0 ml/l	4.68	4.54	1.88	3.70
AAs 2.0 ml/l	5.16	4.67	2.07	3.97
AAs 3.0 ml/l	5.69	4.84	2.36	4.30
SWE 1.5 ml/l	7.39	4.98	2.25	4.87
SWE 3.0 ml/l	6.46	4.68	2.22	4.45
SWE 4.5 ml/l	5.80	4.68	2.17	4.21
Mean (A)	5.64	4.63	2.05	
LSD at 5%	A: 0.35	B: 0.33	AB: 0.57	
Second season (2022/2023)				
Control	3.52	3.15	2.06	2.91
AAs 1.0 ml/l	3.83	3.62	2.58	3.35
AAs 2.0 ml/l	4.76	4.37	2.82	3.98
AAs 3.0 ml/l	6.31	5.60	2.99	4.97
SWE 1.5 ml/l	7.00	6.06	3.43	5.50
SWE 3.0 ml/l	6.28	5.74	3.23	5.09
SWE 4.5 ml/l	6.09	5.28	3.13	4.83
Mean (A)	5.40	4.83	2.89	
LSD at 5%	A: 0.22	B: 0.34	AB: 0.59	

AAs: Amino acids, SWE: Seaweed extract.

Table 8. Effect of planting dates and some growth stimulant substances on fixed oil yield/fed. (l) of chia seeds during 2021/2022 and 2022/2023 seasons.

Growth stimulant treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	139.51	131.66	45.50	105.56
AAs 1.0 ml/l	152.15	147.75	61.09	120.33
AAs 2.0 ml/l	167.78	152.08	67.36	129.07
AAs 3.0 ml/l	185.27	157.48	76.76	139.84
SWE 1.5 ml/l	240.55	162.08	73.08	158.57
SWE 3.0 ml/l	210.07	152.30	72.11	144.83
SWE 4.5 ml/l	188.68	152.04	70.53	137.08
Mean (A)	183.43	150.77	66.63	
LSD at 5%	A: 11.21	B: 10.78	AB: 18.68	
Second season (2022/2023)				
Control	114.54	102.40	67.05	94.66
AAs 1.0 ml/l	124.64	117.72	84.06	108.81
AAs 2.0 ml/l	154.78	142.24	91.75	129.59
AAs 3.0 ml/l	205.50	182.29	97.24	161.67
SWE 1.5 ml/l	227.69	197.29	111.56	178.85
SWE 3.0 ml/l	204.39	186.80	105.14	165.44
SWE 4.5 ml/l	198.31	171.79	101.77	157.29
Mean (A)	175.69	157.22	94.08	
LSD at 5%	A: 7.02	B: 11.01	AB: 19.07	

AAs: Amino acids, SWE: Seaweed extract.

The statistical analysis represents significant interaction impact between the main and sub-plots treatments in both seasons for fixed oil%, fixed oil yield per plant and per fed. Tables (6, 7 and 8). The highest fixed oil% (38.78 and 38.68% in the 1st and 2nd seasons, respectively) was recorded with plants sown in 15th Oct. and sprayed with SWE at 4.5 ml/l. However, the highest fixed oil yield per plant and per feddan (7.39 and 7.0 ml/plant and 240.55 and 227.69 l/fed. in the 1st and 2nd seasons, respectively) were obtained with plants sown in 15th Oct. and sprayed with SWE at 1.5 ml/l.

3.4. Photosynthetic pigments

Data shown in Tables (9, 10 and 11) revealed that planting dates significantly affected the content of the three photosynthetic pigments i.e. chlorophyll a, b and carotenoids in the fresh leaves of chia plants in the two growing seasons). Results showed that the chia which planted on 15th Oct. had the highest chlorophyll a, b and carotenoids contents (3.053, 1.085, and 1.114 mg/g FW, respectively) in the first season and (3.056, 1.084, and 1.115 mg/g FW, respectively) in the second season.

The above-mentioned results were on the line with those of Abdou and El-Sayed (2002) on caraway for planting dates.

It is evident from the obtained data that the three photosynthetic pigments content in the fresh leaves of chia plants were significantly promoted due to spraying the plants with AAs and SWE at all examined concentrations comparing with check treatment in the two growing seasons. Among the tested treatments, the chia plants treated with AAs at 3 ml/l was more effective than other treatments which produced the highest contents of such three pigments in both growing seasons (Tables 9, 10 and 11).

The above-mentioned results were on the line with those of Abd El-Aal and Eid (2018) on soybean, Abd El-Satar (2020) on *Anethum graveolens* and Sowmya *et al*. (2023) on coriander for AAs, as well as, El-Desouky *et al*. (2022) on chia, Al-Hatem (2018) on coriander and Mafakheri and Asghari (2018) and Sujatha *et al*. (2021) on fenugreek for SWE.

Table 9. Effect of planting dates and some growth stimulant substances on the chlorophyll a (mg/g FW) of chia plants during two seasons

Growth stimulant treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	3.020	2.952	2.876	2.949
AAs 1.0 ml/l	3.045	3.028	3.024	3.032
AAs 2.0 ml/l	3.080	3.072	3.052	3.068
AAs 3.0 ml/l	3.097	3.097	3.100	3.098
SWE 1.5 ml/l	3.023	3.000	3.016	3.013
SWE 3.0 ml/l	3.042	3.037	3.029	3.036
SWE 4.5 ml/l	3.061	3.058	3.056	3.058
Mean (A)	3.053	3.035	3.022	
LSD at 5%	A: 0.027	B: 0.030	AB: 0.052	
Second season (2022/2023)				
Control	3.023	2.957	2.878	2.953
AAs 1.0 ml/l	3.048	3.032	3.027	3.036
AAs 2.0 ml/l	3.084	3.076	3.054	3.071
AAs 3.0 ml/l	3.100	3.101	3.102	3.101
SWE 1.5 ml/l	3.026	3.003	3.019	3.016
SWE 3.0 ml/l	3.046	3.041	3.031	3.039
SWE 4.5 ml/l	3.064	3.062	3.058	3.062
Mean (A)	3.056	3.039	3.024	
LSD at 5%	A: 0.027	B: 0.032	AB: 0.056	

AAs: Amino acids, SWE: Seaweed extract.

Table 10. Effect of planting dates and some growth stimulant substances on the chlorophyll b (mg/g FW) of chia plants during two seasons

Growth stimulant treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	1.077	1.060	1.044	1.060
AAs 1.0 ml/l	1.060	1.071	1.067	1.066
AAs 2.0 ml/l	1.093	1.081	1.077	1.083
AAs 3.0 ml/l	1.103	1.092	1.096	1.097
SWE 1.5 ml/l	1.078	1.058	1.058	1.065
SWE 3.0 ml/l	1.089	1.073	1.054	1.072
SWE 4.5 ml/l	1.098	1.080	1.070	1.083
Mean (A)	1.085	1.074	1.067	
LSD at 5%	A: 0.038	B: 0.026	AB: NS	
Second season (2022/2023)				
Control	1.073	1.057	1.057	1.062
AAs 1.0 ml/l	1.082	1.068	1.066	1.072
AAs 2.0 ml/l	1.088	1.077	1.076	1.080
AAs 3.0 ml/l	1.098	1.089	1.095	1.094
SWE 1.5 ml/l	1.073	1.054	1.043	1.057
SWE 3.0 ml/l	1.084	1.070	1.052	1.069
SWE 4.5 ml/l	1.093	1.077	1.069	1.079
Mean (A)	1.084	1.070	1.065	
LSD at 5%	A: 0.038	B: 0.022	AB: NS	

AAs: Amino acids, SWE: Seaweed extract.

Table 11. Effect of planting dates and some growth stimulant substances on the carotenoids (mg/g FW) of chia plants during two seasons

Growth stimulant treatments	Planting dates (A)			Mean (B)
	15th Oct.	1st Nov.	15th Nov.	
First season (2021/2022)				
Control	1.103	1.087	1.073	1.088
AAs 1.0 ml/l	1.112	1.098	1.096	1.102
AAs 2.0 ml/l	1.118	1.107	1.106	1.110
AAs 3.0 ml/l	1.128	1.119	1.125	1.124
SWE 1.5 ml/l	1.103	1.084	1.082	1.090
SWE 3.0 ml/l	1.114	1.100	1.087	1.100
SWE 4.5 ml/l	1.123	1.107	1.099	1.109
Mean (A)	1.114	1.100	1.095	
LSD at 5%	A: 0.038	B: 0.031	AB: NS	
Second season (2022/2023)				
Control	1.104	1.091	1.089	1.095
AAs 1.0 ml/l	1.113	1.105	1.097	1.105
AAs 2.0 ml/l	1.119	1.111	1.109	1.113
AAs 3.0 ml/l	1.129	1.123	1.126	1.126
SWE 1.5 ml/l	1.104	1.088	1.075	1.089
SWE 3.0 ml/l	1.115	1.104	1.084	1.101
SWE 4.5 ml/l	1.124	1.111	1.101	1.112
Mean (A)	1.115	1.105	1.097	
LSD at 5%	A: 0.039	B: 0.033	AB: NS	

AAs: Amino acids, SWE: Seaweed extract.

There was a significant interaction between planting dates and growth stimulant substances applications only on case of chlorophyll a (Table 9) with similar response on both seasons. The highest chlorophyll a content was estimated for the chia which planted on 15th Oct. and treated with 3 ml/l of AAs, respectively.

To discuss and explain the variation of planting dates in improving different vegetative growth characters, seed yield, oil production and Photosynthetic pigments, chia considers as a short-day plant which meaning that early planting date insure extending the vegetative growth phase then the reproductive phase does not expose to low temperature (more than tolerance threshold) compared with the late planting date. Photoperiod, as well as with temperature, are the main environmental factors determining phenology, and yield in photoperiod-sensitive plants (Caliskan *et al*., 2008). Herein, late plantings could delay and decrease seedling emergence as the soil get cold (Egli and Cornelius, 2009 and Lee *et al*., 2008).

Surly many stresses such as unfavorable planting date could disturb the homeostasis phenomena between source and sink in plants (Lemoine *et al*., 2013 and Xu *et al*., 2022). Our findings of the recent research confirm that the inappropriate planting dates could cause abiotic stress on chia plants which negatively affect the metabolic processes, consequently seed yield and oil production. The current study proved that planting on 15th Oct. is the best investigated one for cultivating chia plant in Minia Governorate, as growth, seed parameters, and oil production had higher values than the other ones 1st Nov. and 15th Nov. (Aluko *et al*., 2021).

The relationship between plant N utilization, and concentrations AAs have been suggested by (Liu and lee, 2012). They proposed that the chief role of AAs on crop growth might be linked to the regulation of nitrate uptake and assimilation, but not as sources of reduced N. Amino acids treatment might affect nitrate reductase enzyme that occupying a control signal in the pathway of nitrate assimilation.

Recent study displayed a distinct effect of SWE are widely used in various horticultural crops to promote their growth and development due to their content of complex polysaccharides, fatty acids, vitamins, plant hormones, and

mineral nutrients (Ahmed *et al*., 2017 and Begum *et al*., 2018).

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الملخص العربي

تأثير مواعيد الزراعة وبعض المحفزات الحيوية على نمو وإنتاجية نبات الشيا

أحمد علي حسن وإيمان جمعه عباس ورجاء علي طه

قسم البساتين، كلية الزراعة، جامعة المنيا.

تم تنفيذ تجربة حقلية خلال الموسمين المتتالين ٢٠٢٢/٢٠٢١ و ٢٠٢٣/٢٠٢٢ بمشتل نباتات الزينة، كلية الزراعة، جامعة المنيا. تم تصميم التجربة بنظام القطاعات تامة العشوائية بنظام القطع المنشقة مرة واحدة في ٣ مكررات، العامل الرئيسي زراعة بذور الشيا في ١٥ أكتوبر، ١ نوفمبر، ١٥ نوفمبر، بينما العامل الثانوي رش النباتات بالأحماض الأمينية بتركيز ١ و ٢ و ٣ ملليلتر/لتر و مستخلص الأعشاب البحرية بتركيز ١,٥ و ٣ و ٤,٥ ملليلتر/لتر، إضافة إلي معاملة الكنترول. في كلا الموسمين، تأثرت صفات ارتفاع النبات، عدد الأفرع، الأوزان الجافة للأعشاب، محصول البذور/نبات وللفدان، وكذلك إنتاجية الزيت الثابت وصبغات البناء الضوئي تأثراً معنوياً بمواعيد الزراعة وكذلك إضافة المواد المحفزة للنمو. أيضاً، كان هناك تفاعل معنوي بين معاملات العامل الرئيسي ومعاملات العامل الثانوي، بإستثناء عدد الفروع للنبات في الموسم الثاني والوزن الجاف للنبات في الموسم الأول والكلورفيل "ب" والكاروتينويدات في كلا الموسمين.

عموماً، تم تحقيق أفضل معاملات التداخل من خلال موعد الزراعة الأول (١٥ أكتوبر) بالاشتراك إما مع الأحماض الأمينية عند ٣ مل/لتر لارتفاع النبات ومتوسط عدد الأفرع والوزن الجاف للعشب/النبات والصبغات الضوئية الثلاثة، أو مع مستخلص الأعشاب البحرية بمعدل ١,٥ مل/لتر لإنتاجية البذور والزيت الثابتة.

الكلمات المفتاحية: الشيا، مواعيد الزراعة، الأحماض الأمينية، الأعشاب البحرية.