STIMULATIVE RESPONSE TO QUANTITY AND QUALITY OF JOJOBA OIL BY GIBBERELLIC ACID AND BENZYL ADENINE

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ABSTRACT

This study was aimed to evaluate five clones of jojoba plant under the influence of salinity stress which was spraied by gibberellin and benzyl adenine on growth yield and oil. Two field experiments were carried out at Magharah Research and dmting Production which follow Desert Research Center, Agriculture Ministry, in North Sinai governorate, Egypt, 2015/2016 and 2016/2017 respectively, the experimemts wene consist of five clones (S-L, S-610, S- 700, S-B and S-G), (were sprayed by, GA_3 200ppm, BA 200ppm and GA_3+BA and control) under effect of salinity stress. The experiment was conducted as split plot design having varieties in main plot and IAA, GA_3 sub plots three replicates. The jojoba plant was affected by increased GA_3, BA or/and GA_3+BA, and it was clear in all clones. The effect of GA_3, BA or/and GA_3+BA varied from one clone to another and the lowest was s-700. All studied variables were confirmed that clones of jojoba had a significant effect with GA_3, BA or/and GA_3+BA

Key words: oil yield, water salinity, spray acid, sinai, water stress.

استجابة كمية وجودة زيت الجوجوبا للتحفيز بحمض الجبريليك والبنزيل أدينين

السيد عبد الله خطاب ابتسام عبدالعزيز الحسينى إلهام عبد المنعم بدر
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قسم بحوث المحاصيل ، قسم الزراعة والبيولوجيا ، المركز القومي للبحوث ، القاهرة ، مصر.

المستخلص

تهدف هذه الدراسة إلى تقييم خمس سلالات من الجوجوبا تحت تأثير الإجهاد الملحي برش النباتات بحامض الجبريليلين وحامض بنزيل أدينين وأثر ذلك على النمو وإنتاجية الزيت. تم إجراء تجربتين حقليتين في محطة المغارة للأبحاث والإنتاج التي تتبع مركز بحوث الصحراء, وزارة الزراعة التى تقع في محافظة شمال سيناء، مصر، خلال السنتين 2016/2015 و2017/2016, لخمسة سلالات جوجوبا هى (SL، S-610، S - 700، SB و SG)، وتم رشها بتركيز (GA_3 200ppm، BA 200ppm و GA_3 + BA) بالاضافة الى المقارنة تحت تأثير ملوحة مياه الرى. نفذت التجربة بتصميم الالواح المنشقة ووزعت السلالات فى الالواح الثانوية والمعاملات (IAA و GA_3) فى القطع الفرعية وتم توزيعها في ثلاث مكررات. أشارت النتائج الى تأثر الجوجوبا بزيادة GA_3 أو BA أو / و BA + GA_3 ، وكان ذلك واضحًا في جميع السلالات. وتباينت تأثيرات GA_3 أو BA أو / و BA + GA_3 من سلالة لآخرى وكان أقلها استجابة السلالة s-700. وأكدت جميع الصفات التي تم دراستها أن سلالات الجوجوبا كانت متأثرة بشكل كبير بالرش بكل من GA_3 أو BA أو / و BA + GA_3.

كلمات مفتاحية: حاصل الزيت، ملوحة المياه، ملوحة التربة ، سيناء.

***Received:21/12/2018, Accepted:4/4/2019**

INTRODUCTION

Jojoba, *Simmondsia chinensis* (Link) Schneider, is native to the Sonoran desert. The seeds of jojoba contain a light-gold-colored wax ester (jojoba oil) that makes up 50–55% of the seed weight. Jojoba is an extremely salinity water stress species and is gaining worldwide attention, for extraction of oil which is used in pharmaceuticals and lubricant industries as a replacement of sperm whale oil. Jojoba is a high cash crop and Industrial, and it is need to low production costs for its quality of growth in all circumstances. In recent years, renewed interest in commercial cultivation of jojoba has begun as the useful properties of the liquid wax obtained from the seed have been confirmed(20, 29) Salinization threatens the productivity of agricultural land and agricultural sustainability. Salinity is a major problem that negatively affects agricultural activities in many regions in the world, salinity problems increase with increasing salt concentration in irrigation water. Crop growth reduction due to salinity is generally related to the osmotic potential of the root zone soil solution, (2). Water used for irriga tion can vary greatly in quality depending on type and quantity of dissolved salts. Almost 50% of the irrigated land is affected by high salinity, often resulting in secondary salinization due to inappropriate use of saline irrigation water. Despite the essentiality of chloride as a micronutrient for all higher plants and of sodium as mineral nutrient for many halophytes and some species, salt accumulation may convert agricultural areas in unfavorable environments, reduce local biodiversity, limit growth and reproduction of plants, and may lead to toxicity in nonsalt-tolerant plants, known as glycophytes (6, 33). The effects of salinity are generally summarized as water stress, salt stress and stress due to ionic imbalance (14). Therefore at least one part of salt stress is associated with water stress, which is a general condition, and it can be expected that plant adaptation to salinity may show features similar to those characteristic of adaptation to water stress. It was believed to be future arid plant, in general, jojoba developed reasonably well under salinities of 8 dSm^{-1} (9). Salinity and drought are considered to be the most serious growth-limiting factors for crop plants (11, 41). Increasing salinity of irrigation water has contributed to progressive salinization of agricultural soils inhibiting agricultural productivity in many semi-arid and arid regions of the world (35). Sodium chloride (NaCl) is the most commonly encountered source of salinity (24). Much of the strain in salinity stress is related to water stress arising from excessive uptake of salts by the plants and the resulting reduction in water potential. For this crop to be an economically profitable alternative for arid and semi-arid zones, it is necessary to first select plants of high productivity that also possess sufficient resistance to abiotic stresses. Salinity is considered to be the most serious growth limiting factors for crop plants (4, 41). In spite of information showing that jojoba tolerates fairly high levels of salinity (9) and water stress the selections to date have not been intended for use in regions with extremely high levels of salinity and water stress (10). Therefore, the aim of this study was to evaluate the effect of salinity concentrations on shoot and root growth, leaf measurements and chemical constituents of jojoba leaves, (18). The stimulative response of gibberellic acid, which known to be one of the endogenous growth regulators, and could be attributed to its unique roles in plant growth and development as reported by many investigators. (3) suggested that GA_3 has the capability of modifying the growth pattern of treated plants.(39) Gibberellic acid is used to regulation plant growth through increasing affecting the DNA and RNA levels, cell division and expansion, biosynthesis of enzymes, protein, carbohydrates and photosynthetic pigments. GA_3 treatment increased significantly shoot growth (shoot length, number of leaves, number of branches and leaf area) and root growth (root length, number of roots & root thickness) compared to the conrol, (53) and (22). The effect of benzyl adenine on the plant growth and chemical constituents of different plants have mentioned by (153); (33); (34); (32) and (51). Studies of exogenous applications of various plant growth regulators (PGRs) showed that PGRs play important roles in floral development (27); (19); (47). Exogenous cytokinin (CK)

application has been shown to increase meristem activity and promote floral initiation in several species (54); (55); (24). Ohkawa (40) and (23) found that 6-benzyladenine (BA), a synthetic compound with CK activity) treatment had a significant influence on increasing flower numbers of *Lilium speciosum*, particularly when combined with gibberellins. Chen (13) showed that flower bud differentiation of lychee (*Litchi chinensis*) was significantly promoted by exogenous kinetin application after bud dormancy. The total number of flowers on jojoba (*Simmondsia chinensis*) was also significantly increased by treatment with BA (45); (43). Most of the criteria of vegetative growth expressed as number of leaves/plant, leaf area and petiole length and were significantly affected by application of GA_3 and BA. GA_3 and BA separately promoted all the aforementioned characters in this study compared with control plants; Parviz rahbarian, et al., (42). The aim of this study is investigation of five clones of jojoba plants (S-L, S-610, S- 700, S-B and S-G), were spray by (control, GA_3 200ppm, BA 200 ppm and GA3+BA) that growing under effect of water salinity stress.

MATERIALS AND METHODS

Plant and Treatments

Jojoba plants were cultivated in Almaghara Research and Production Station (latitude: 30,717993"N, longitude: 33, 329103 E) followed to Desert Research Center, Agriculture Ministry, Egypt at 2015/2016 and 2016/2017 respectively. Two field experiments were carried out for five clones (S-L, S-610, S- 700, S-B and S-G), to study the effect of spray Gibberellic acid GA_3 200 ppm and Benzyl adenine BA 200 ppm and interaction between them on jojoba plants at four years old from planting to investigation content seed from oil and other chemical contents.

Experimental device

The experimental rows (5 plants each) were assigned for each clone in each replication. Distances between rows and within plants in rows were 3 and 2 m. respectively. Plants (mixed males and female seedlings) derived from the open population, as a source of pollen, were repeated one row every six female (clone) rows. Additional border mixed seedling rows were planted around each replication and no free space was left between rows within each replication to ensure homogeneity within each replication. The main physical and chemical properties of the soil of the experiment) and water irrigation analysis are shown in Table 1(a and b). A drip irrigation system was installed in the experimental areas and weed control were done as necessary applied in the course of the study. All clones were treatment at three times (October, March and April) with concentration of Gibberellic acid and Benzyl adenine.

Table 1a. Main physical and chemical properties of the soil at 2015/2016 and 2016/2017

Character	At 0-30cm	At 30- 60 cm
Fine sand (%)	81.4	84.8
Silt (%)	8.2	4.5
Clay (%)	11.28	10.7
Texture	Sandy	Sandy
Organic matter (%)	0.93	0.85
pH	7.9	7.88
EC (mmhos/cm^2)	2.84	2.46
$CaCO_3$	1.38	1.11
SO_4	4.89	4.56
HCO_3	1.24	1.11
Total N (%)	5.6	4.1
Available P (%)	4.7	4.3
K (%)	4.55	5.6
Mg %	3.21	3.78
Fe (ppm)	1.43	1.3
Zn (ppm)	0.5	0.35
Mn (ppm)	1.3	1.2
Na+	20.41	19.66
Cl-	22.15	21.25
Ca++	2.27	2.14

Table 1b. Chemical characteristics of water weal used for the present study

Parameters	pH	EC(dSm^{1})	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}
Values	7.49	3.77	5.44	3.56	21.83	3.21	1.96	28.21	3.22

Determination of growth/ yield parameters of plants: Vegetative and reproductive measurements: Data were collected from tagged plants of each clone for each block: plant height; branch characters: Two branches were selected from the mid- level of the plants and the average of two branches characters were calculated for detailed analysis. From each branch the following data were collected; number of main branches/plant, stem diameter (cm), number of nodes/stem, length of node (mm), leaf number of leaves/plant, leaf width (mm), length (mm) and leaf area (cm^2), and this last character was calculated as mentioned by Koller (22). Leaf area (cm^2) was estimated from the following equation:

Leaf area = 0.717 X – 0.095,

which X is the product of length by width, Kohorn, (4). Chlorophyll contents were assayed in the commercial harvest stage. They were determined according to Wintermans and Mats (45) as follows: half gram of fresh leaves was extracted by about 15 ml. of 85% acetone with 0.5 g calcium carbonate, the mixture was through a glass funnel and the residue was washed with a small volume of acetone and completed to 25 ml. The optical density of Journal of a constant volume of filtrate was measured at a wave length of 622 nm for chlorophyll A, 644 nm and for chlorophyll B using spectrophotometer

Seed yield: Seed were harvested from the previous tagged plants by hand at full maturity. Harvested seeds were cleaned, dried and weighted (g). Seeds were hand-harvested every year in July and August from five plants per clone and used for determining seed yield plant^{-1} (g) and analyzed for main components. Oil content was determine oil content, seeds of each genotype were randomly selected, weighed, and dried at 50 ºC. The drying process was continued until the difference between the two successive weights was less than 1 mg five replications were used for this characteristic. The oil was extracted for 16 h with hexane with a Soxhlet apparatus. Total carbohydrates: Total carbohydrates were estimated by the difference in the mean values, i.e., 100 - (sum of concentrations of protein, ash and lipid). Determination of total carbohydrates was determined spectrophotometrically (as glucose) after acid hydrolysis using phenol sulphuric acid reagent, according to (11). Mineral content: To remove carbon, approximately 5gm of each dry sample was ignited in a porcelain container and incinerated in the muffle furnace at about 550oC. Mineral content was expressed as a percentage of dry matter. Total Nitrogen content determined using Micro-Kjeldahl method Jackson (20). Protein content was determined by the Kjeldahl method for the calculation of all proteins which equal nitrogen content multiplied by 6.25, AOAC (3). Potassium content was extracted according to Chaudhary et al. (12). Phosphorous content using chlorostannous reduced molybdo-phosphoric acid blue color method, in hydrochloric described system as described by Jackson (20). Magnesium Mg %, Zinc Zn m/kg, copper Cu m/kg and iron Fe m/kg assay by atomic absorption.

Statistical analysis

The experiment was conducted as split plot design having varieties in main plot and IAA, GA_3 sub plot and distributed in three replicates. Statistical analyses and mean comparisons were conducted using MSTAT-C software. (38).

RESULTS AND DISCUSSION

All data in Tables 2, 3 and 4 show that the foliar application of gibberellic acid or/and benzyl adenine lead to increase of all growth characters as plant height (cm), number of main branches/plant, stem diameter (cm), number of nodes/stem, length of node (mm), leaf number of leaves/plant, leaf width (mm), leaf length (mm) and leaf area (cm^2) and, yield characters as total number of branches, number of leaves, weight of seeds/plant (kg), weight of seed (gm.), weight 100 seeds (gm.) and oil content of the seeds %, Some chemical contents in leaves as chlorophyll content (chl. A, Chl. B and carotene); total Carbohydrates, nitrogen%, phosphorus%, Potassium%, Fe ppm, Zn ppm, Cu ppm and Mg ppm. All characters affected by increase in GA_3 and BA under clone S-700. Data presented in Table 1 and 2 show that, the foliar application of different concentrations of gibberellic acid

(GA_3) and benzyl adenine (BA) had significantly stimulatory effect on growth parameters of jojoba plants in term of plant height, number of branches, and leaves/plant and leaf area compared with the untreated plants, as this respect Afifi et al., (3), (5, 37).

Table 2. Effect of rates of GA_3 and BA and clones of jojoba plants on growth characters

Clones / Treatments		shoot characters					leaves characters			
		plant height (cm)	number of main branches/plant	stem diameter (cm)	n umber of nodes/stem	Length of node (mm)	leaf number of leaves/plant	leaf width (mm)	length (mm)	leaf area (cm^2)
S-L	0	73.21	2.448	1.282	15.04	11.19	87.46	27.68	38.11	7.672
	GA_3 200ppm	76.77	2.569	1.345	16.43	12.30	92.60	28.72	38.36	7.994
	BA200ppm	78.14	2.975	1.557	16.67	12.42	99.57	28.20	39.04	8.146
	GA_3+BA	79.74	3.036	1.589	17.04	12.67	101.64	28.78	39.84	8.316
S-610	0	74.78	2.521	1.319	15.54	11.59	90.035	27.73	38.19	7.712
	GA_3 200ppm	78.36	2.646	1.385	16.78	12.53	101.61	28.78	38.43	8.054
	BA200ppm	79.70	3.064	1.603	16.92	12.64	108.39	29.44	38.60	8.448
	GA_3+BA	81.33	3.127	1.637	17.39	12.91	110.60	30.04	39.39	8.614
S- 700	0	76.25	2.598	1.359	15.80	11.81	92.805	27.79	38.26	7.786
	GA_3 200ppm	79.97	2.725	1.425	16.78	12.53	104.47	30.11	38.51	8.491
	BA200ppm	81.38	3.156	1.651	17.80	13.34	111.88	29.50	38.67	8.528
	GA_3+BA	83.04	3.221	1.686	18.27	13.61	114.16	30.11	39.47	8.706
S-B	0	75.53	2.572	1.346	15.67	11.68	91.479	27.76	38.22	7.746
	GA_3 200ppm	79.18	2.699	1.412	16.91	12.60	100.32	28.81	38.47	8.091
	BA200ppm	80.48	3.125	1.636	17.42	12.97	106.45	29.55	38.63	8.482
	GA_3+BA	82.14	3.189	1.669	17.89	13.29	108.63	30.07	39.43	8.668
S-G	0	74.01	2.497	1.307	15.29	11.43	88.749	27.70	38.15	7.680
	GA_3 200ppm	77.63	2.620	1.371	16.66	12.42	97.752	28.75	38.40	8.021
	BA200ppm	78.97	3.034	1.588	16.89	12.53	103.34	29.40	38.56	8.410
	GA_3+BA	80.59	3.096	1.620	17.166	12.801	105.46	30.01	39.35	8.582
	LSD C	13.222	0.8137	0.0833	2.0332	2.866917	15.867	7.4419	8.7928	0.84686
	LSD T	11.413	0.4603	0.0485	4.3042	2.76033	13.504	4.7233	8.0646	0.57374
	LSD C x T	8.098	0.2757	0.0373	4.1717	1.814712	10.080	2.8561	6.3975	0.20779

Table 3. Effect of rates of GA_3 and BA and clones of jojoba plants on yield

Clones / Treatments		total number of branches,	No. leaves	W, Seeds harvest (kg)	Weight of seed gm	Weight (100 seed gm)	oil content of the seeds %
S-L	0	7.87	125.62	66.64	0.6758	67.58	40.05
	GA_3 200ppm	8.26	132.97	67.99	0.7155	71.55	45.42
	BA200ppm	9.47	141.51	67.33	0.8097	80.97	47.62
	GA_3+BA	9.76	145.89	69.41	0.8348	83.48	49.09
S-610	0	8.11	129.29	70.59	0.6957	69.61	41.44
	GA_3 200ppm	8.51	145.89	72.04	0.7354	73.70	46.41
	BA200ppm	9.75	153.65	71.35	0.8386	83.42	49.36
	GA_3+BA	10.05	158.41	73.55	0.8646	86.00	50.88
S- 700	0	8.35	133.56	74.74	0.6957	69.68	42.44
	GA_3 200ppm	8.76	150.85	76.11	0.7354	73.78	48.10
	BA200ppm	10.04	159.24	75.36	0.8386	83.50	50.42
	GA_3+BA	10.35	164.18	77.70	0.8646	86.08	51.98
S-B	0	8.27	131.98	72.57	0.6857	68.99	41.64
	GA_3 200ppm	8.68	144.30	74.07	0.7354	73.05	46.81
	BA200ppm	9.95	151.44	73.36	0.8290	82.68	49.74
	GA_3+BA	10.25	156.12	75.63	0.8546	85.24	51.28
S-G	0	8.03	127.41	67.62	0.6857	68.93	40.85
	GA_3 200ppm	8.42	140.32	69.00	0.7254	72.98	45.91
	BA200ppm	9.66	146.91	68.34	0.8290	82.59	48.49
	GA_3+BA	9.95	151.45	70.45	0.8546	85.15	49.99
	LSD C	2.09783	31.0123	9.29889	0.31861	9.8492	9.2233
	LSD T	1.95182	22.9740	8.73443	0.00998	8.3286	7.9494
	LSD C x T	1.54885	17.1969	7.13716	0.00222	7.5144	8.0442

The most effective treatment which had the tallest plants, the largest leaf area and the highest number of leaves was (GA_3) when applied at concentration of 200 ppm. The results are in agreement with (37) and (15); (39) and Soad (2005) on Jojoba plant. However, (GA_3) is used to regulating plant growth through increased meristimatic activity due to enhance cell division and elongation Treatment with BA at 150 ppm gave the highest value of the number of branches/plant compared with the other treatments and control.

Table 4. Effect of rates of GA_3 and BA on clones of jojoba plants on content of leaves from chemical content

Clones / Treatments		Chlorophyll 51Content			Total Carbohydrates	Nitrogen%	phosphorus%	Potassium%	Fe ppm	Zn ppm	Cu ppm	Mg ppm
		Chl.A	Chl. B	Carot.								
S-L	0	2.006	1.503	2.857	9.987	2.484	0.235	1.513	1218.2	4275.3	1207.3	0.7474
	GA_3 200ppm	3.045	1.671	3.283	11.964	3.155	0.244	1.949	1436.6	4709.6	1217.2	0.8887
	BA200ppm	3.352	1.840	3.613	13.170	3.474	0.268	2.146	1581.8	5185.2	1340.8	0.9784
	GA_3+BA	3.836	1.693	4.005	13.250	3.187	0.276	2.022	1635.4	5153.6	1228.1	0.9591
S-610	0	2.956	1.563	3.075	10.679	2.731	0.261	1.877	1232.8	4291.6	1219.3	0.7831
	GA_3 200ppm	3.440	1.738	3.322	13.151	3.214	0.272	2.182	1453.8	4728.5	1229.3	0.9314
	BA200ppm	3.787	1.914	3.662	14.480	3.539	0.299	2.402	1600.7	5206.0	1353.8	1.0255
	GA_3+BA	4.469	1.801	4.884	13.448	3.305	0.296	2.221	1655.0	5174.1	1240.3	1.0056
S-700	0	2.956	1.563	3.075	10.679	2.731	0.261	1.877	1232.8	4291.6	1219.3	0.7831
	GA_3 200ppm	3.440	1.738	3.322	13.151	3.214	0.272	2.182	1453.8	4728.5	1229.3	0.9314
	BA200ppm	3.787	1.914	3.662	14.480	3.539	0.299	2.402	1600.7	5206.0	1353.9	1.0255
	GA_3+BA	4.469	1.801	4.884	13.448	3.305	0.296	2.221	1655.0	5174.1	1240.3	1.0056
S-B	0	2.857	1.595	3.085	11.173	2.692	0.273	1.900	1544.0	5194.0	1210.4	0.7883
	GA_3 200ppm	3.124	1.773	3.411	13.350	3.237	0.284	2.091	1468.4	4742.6	1221.3	0.9360
	BA200ppm	3.439	1.952	3.751	14.699	3.567	0.312	2.302	1616.7	5221.6	1344.6	1.0390
	GA_3+BA	4.301	1.835	4.450	13.547	3.318	0.305	2.215	1671.6	5189.7	1250.3	1.0113
S-G	0	2.827	1.533	3.045	10.383	2.641	0.240	1.844	1525.6	5173.4	1198.4	0.7657
	GA_3 200ppm	3.094	1.705	3.381	13.052	3.176	0.271	2.030	1451.1	4723.8	1209.6	0.9089
	BA200ppm	3.406	1.877	3.721	14.369	3.495	0.298	2.235	1598.5	5200.9	1331.3	1.0016
	GA_3+BA	4.261	1.764	4.409	13.349	3.254	0.284	2.151	1651.7	5169.0	1238.0	1.0133
LSD C		0.08679	0.02278	0.05993	4.79572	0.11263	0.01032	0.12484	153.860	923.162	2.31739	0.00935
LSD T		0.07822	0.02214	0.09418	4.55733	0.10083	0.00956	0.11245	138.526	831.195	0.18954	0.00858
LSD C x T		0.00272	0.00338	0.12964	4.24344	0.10151	0.00557	0.10725	131.997	792.041	0.19041	0.00818

According to Table 4 it was found that the leaves content of three photosynthetic pigments chlorophyll (chl. a and chl. b) and carotenoids were gradually increased as the concentration of GA_3 and BA were increased. The highest value of Chl (a and b) and carotenoids was obtained at concentration of GA_3 (200 ppm). The results herein are agreement with the finding of Mousa et al., (30) on Nigella sativa, (37) and (5) they mentioned that GA_3 treatments were more effective than kinetin in increasing photosynthetic pigments in croton leaves. Application of GA_3 and BA with 200ppm concentrations were favorable for accumulation of total soluble sugars in leaves of the tested plants compared with the control. The greatest content of total soluble sugars occurred in the leaves of plants treated with GA_3 and BA at 200 ppm. In harmony with these results were those obtained by (37) and (31) and Nahed (39) on flax plants recorded that GA_3 and BA application resulted in an increase of total soluble sugars content. These results are in line with those obtained by Lobna et al., (25). This study clearly demonstrated that growth hormones, whether alone or in combination, have a major impact in the stimulation of various growth parameters in jojoba plants. It was concluded that plant growth hormones could be successfully employed for enhancement of seed yield, directly or indirectly, through its components. Increase oil content by application of plant growth regulators on jojoba. The salt stress has a significant impact on the productivity of jojoba. The treatment of growing plants under the influence of Sinai salinity with gibberellic acid GA_3 and benzyl adenine used as growth regulators induces the accumulation of substances such as antioxidants and photosynthesis products which reduces the effect of salinity, especially with S-700 clone.

ACKNOWLEDGEMENT
The authors would like to thank the National Research Centre for financial support of this study as a project is number 11030125. The authors also wish to thank the manager and staff of production and research station of Maghara at the north of Sinai government, Desert Research Center, for providing facilities and technical assistance.

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