



Effect of low temperature and seaweed extracts on flowering and yield of cantaloupe plants under sandy soil

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Abstract

The study was conducted at the Ismailia Station for Agricultural Researches, which is affiliated with the Agricultural Research Centre in Giza, Egypt, during the winter seasons of (2021 and 2022). The aim of this study is to evaluate the impact of exposing the seeds to a low temperature (4 °C) before planting and treating the plants with spirulina extract on the flowering process and cantaloupe yield (Milagro F1) grown in greenhouse conditions with sandy soil. The experiment involved two factors. The first factor was the number of days the seeds were cooled at 4 °C before planting (0, 1, 2, or 3 days). The second factor was the application of spirulina extract to the seedlings after the cotyledon leaves opened and after 15 days of cultivation (0, 1.5 ml, or 3 ml concentrated spirulina per liter of water). The study used a factorial randomized complete block design within a split plot system. The means were compared using the Duncan multiple range test at a significance level of 5%. The characteristics of growth, flowering, yield, and fruit quality were studied. The results showed that increasing the number of cooling days as well as spraying spirulina extract till 1.5 ml/liter resulted in the highest growth, flowering, and yield of the cantaloupe plant. The greatest results were obtained by cooling the seeds for three days and spraying with spirulina at 1.5 mL/L. Increasing the spirulina spray rate to 3 mL/L lowered the distinguishing features when compared to 1.5 mL/L. To summarize, to improve cantaloupe flowering, growth, and yield with spirulina alone, spraying at a defined time until 1.5 ml/liter extract is demand; however, to improve by cooling seed alone, cooling seeds for 3 days before transplanting at 4 C; and the maximum improvement obtained by interacting at both levels from different two factors.

Keywords: Cantaloupe, low temperature, seaweed extracts, spirulina, spraying

Introduction

Cantaloupe (*Cucumis Melo* L.) is considered one of the significant food crops in the cucurbitaceae family, alongside watermelon, cucumber, melon, and squash (Robinson and Decker-Walters, 1997) ^[1]. Its popularity has grown in recent years due to its delightful taste and appealing flavor.

Several strategies are now being researched to improve productivity, quality, and early flowering. One of these concepts is to use low temperatures to successfully promote plants to commence flowers sooner, resulting in an enhanced quantity of flowers (Barten *et al.*, 1992) ^[2]. Low temperature is considered an important abiotic stress factor for plant development, yield, and energy distribution (Oufir *et al.*, 2008) ^[3]. According to Foley *et al.* (2009) ^[4], when the herbaceous weed *euphorbia esula* L. was gradually exposed to decreasing temperatures, it exhibited a fast re-growth and flowering. Tewari *et al.* (2009) ^[5] found that exposed cucumber seeds Variety Jyoti Green to 4 C° for varying lengths (0, 24, 48, and 72 hours) before germinating and growing under regular conditions for two weeks had a significant impact on the flowering response in cucumber. The impacts of lower temperatures upon photosynthetic product translocation and carbohydrate metabolism can affect how plants grow and develop, as well as yield and fruit quality (Hongyan *et al.*, 2011) ^[6].

The use of algal extracts is another recommended approach to promote flowering and productivity. Today, seaweed extracts provide an appropriate substitute since they include not only vital nutrients such as NPK, but also a broad variety of molecules with varying architectures. These

extracts may contain phytohormones or plant extracts that are metabolically active, such as amino acids and organic acids, as highlighted in the study conducted by Ahmed and Shalaby in 2012 ^[7]. According to previous studies (Abd El Moniem and Abd-Allah, 2008 ^[8]; Sathya *et al.*, 2013) ^[9], it has been noted by researchers that seaweed extracts possess a diverse range of beneficial substances for plant growth. These include cytokinins, auxins, betaines, gibberellins, amino acids, macronutrients, trace elements, and other organic substances. These components have the potential to enhance both crop and quality. Moreover, the application of alga extract, which contains several macro and micronutrients, along with growth regulators, polyamines, and vitamins, has shown positive effects on improving the nutritional status, vegetative growth, yield, and fruit quality in various types of orchards and vineyards. The application of seaweed extract for various crops is highly beneficial as it contains a significant amount of organic matter, microelements, vitamins, and fatty acids. Additionally, it is rich in growth regulators such as auxins, cytokinins, and gibberellins (Crouch and Van Staden, 1994) ^[10]. Seaweed liquid fertilizers can be valuable in achieving enhanced agricultural production due to the presence of growth promoting hormones like IAA and IBA, cytokinins, gibberellins, trace elements, vitamins, amino acids, antibiotics, and micronutrients (Booth, 1965) ^[11]. Because seaweeds have antibacterial action against bacteria, yeast, and molds, Zhang and Schmidt (2000) ^[12] discovered that seaweed extracts increased cucumber resistance to illnesses. They also discovered that seaweed extracts boosted plant growth, yield, and quality by influencing cell metabolism

through the stimulation of antioxidant molecule formation, which might promote plant development and stress tolerance. Riley (2002) ^[13] discovered that soil treatment with the seaweed extract Algal fibre at levels (20 and 40 kg/hectare) resulted in a considerable increase (30-70%) in potato output. Masny and Zurawicz (2004) ^[14] discovered that utilizing seaweed in two concentrations (0, 0.1) ml.l⁻¹ on two strawberry kinds (Salut, Elkat) greatly boosted the plant's qualitative properties such as total soluble solids and vitamins C. Blunden and Paul (2006) ^[15] observed a considerable increase in overall yield after spraying two potato cultivars (King Edward and Pentlanddell) with seaweed extracts. Eris *et al.* (2008) ^[16] found that treating pepper cultivar California Wonder with seaweed extract (*Ascophyllum nodosum*) resulted in larger fruit size. In a study conducted by Gajewski *et al.* (2008) ^[17], it was found that the use of Geteo, an organic-mineral fertilizer that includes *Ascophyllum nodosum* algae extract and phosphorus, greatly increased the productivity, quality, and vitamin C levels of two types of Chinese cabbage. According to Abd El Moniem and Abd-Allah (2008) ^[8], algal extract application greatly stimulated grapevine growth characters such as leaf area, shoot length, and number of leaves/shoot, and yield expressed as weight and number gradually improved in response to increasing algal extract concentrations. According to Al-Jebbouri (2009) ^[18], foliar spray with the seaweed for cucumber plants make considerably altered in male or female numbers of flowers, the sex ratio, and overall output of crop. According to Abdel Mawgoud *et al.* (2010) ^[19], applying seaweed extract by different doses 1 to 3 g/L of watermelon enhanced overall growth indicators and yield. Sarhan (2011) ^[20] conducted experiments to investigate the influence of two seaweed extracts (alga) and humic acid on potato plants. This application gave a significant positive effect on quantitative yield characteristics and their interactions. According to Shehata *et al.* (2011) ^[21], it was found that the application of seaweed extracts to plants resulted in a noteworthy increase in root yield. Additionally, when plants were treated with a combination of seaweed extract and amino acid, there was a significant increase in the overall sugar content. Similarly, Mohammed (2013) ^[22] discovered that treating pepper plants with seaweed extracts had a positive and notable impact on various factors such as plant height, chlorophyll content, total yield, fruit size, and vitamin C levels. These findings were observed in comparison to untreated pepper plants. Sarhan and Ismael (2014) ^[23] conducted a study to examine the impact of seaweed extracts (seaforce and seamino) on the yield and flowering of two cucumber cultivars. The extracts were applied at concentrations of 0.0 and 1.5ml/L, and the cucumbers were exposed to low temperatures for durations of 0, 5, and 10 days. The extracts were sprayed three times with a gap of seven days between each application. The findings of the study revealed that the use of both extracts resulted in a significant improvement in the number of female flowers, fruit setting percentage, and cucumber yield. This improvement was observed in various aspects such as the number of fruit per plant, fruit weight, yield per plant, yield per square meter, and total yield. Spirulina is a type of microalgae that has a photosynthetic nature, with a unique spiral shape and green-blue color. It is composed of various essential components such as proteins, carbohydrates, fatty acids, vitamins, minerals, and pigments like carotenes, chlorophyll a, and phycocyanin. Through its

metabolic processes, Spirulina releases different substances including organic acids, vitamins, and phytohormones. It has been observed that Spirulina contains significant amounts of acrylic acid, which has been shown to exhibit antimicrobial properties at a concentration of 2 mg/L of biomass. Additionally, other organic acids like propionic, benzoic, and mandelic have also been identified in Spirulina (Balloni *et al.*, 1980) ^[24].

To possibly improve flowering and production, study on application characteristics such as mode and time of application, as well as the amount of additive employed, may be advantageous. The goal of this study is to look into these important factors and provide insight into the impact of exposing cantaloupe seeds to low temperatures before planting and treating plants with spirulina extracts on cantaloupe flowering and yield in sandy soil.

Materials and Methods

The experiment took place in a greenhouse at Ismailia Station for Agricultural Researches, which is affiliated with the Agricultural Research Center in Giza, Egypt, during the winter seasons of January 10th, 2021-2022. The cantaloupe cultivar used was Milagro F1, and it was provided with a drip irrigation system. Spirulina was obtained from a farm in Al-Saeed farms in Abu Sweir, Ismailia governorate. The Spirulina sample was carefully handpicked and promptly rinsed with distilled water to eliminate any foreign particles, sand particles, and epiphytes. It was then drained using strainers, spread on blotting paper to remove excess water, frozen, and subsequently thawed at room temperature. The resulting melted mixture was further processed by centrifuging it at 5000 rpm to obtain a clear cell sap. The resulting supernatant was collected as 100% spirulina extract and stored in a frozen state for further studies. The spirulina foliar spraying was prepared using varying doses of 0, 1.5, and 3 ml of 100% spirulina extract per liter of water. The cantaloupe seeds were subjected to a low temperature of 4 °C for different durations (0, 1, 2, and 3 days) prior to planting. Afterwards, the seedlings were sprayed with algae extract (spirulina) after the cotyledonous leaves had opened, using spirulina at rates 0, 1.5 ml, and 3 ml per liter of water. Following the seedlings are sprayed 15 days after planting. The experiment comprised of two factors; the first factor was days of cold, the second factor was spraying with three concentrations of spirulina extracts (0, 1.5, 3 ml/litre). The factorial Randomized Complete Block Design within split plot system was used. The main plot was represented by low temperature and the sub plot was represented by concentrations of spirulina extracts. Cantaloupe seeds were sown in a cultivation tray previously filled with two seeds per gap on December 1, 2020–2021, and then planting in a greenhouse at 10 January 2020 to 2021. The experiment includes 12 treatments, each of which is repeated three times, and each of which represents 20 plants (10 m²), with 50 cm interspace between plants. The plastic house soil was sandy.

Response Parameters

The plant height, leaves number, leaf area, fresh, dry weight and male and female flower number were estimated. The chlorophyll was measured in leaf samples according to Arnon (1949) ^[25]. The crop measurements (fruit/plant quantity, average fruit weight (gram), plant yield (gram per plant), plot yield (kg) and total yield (tons per fed.) were determined. Total soluble solids (TSS), pH, total acidity

(AOAC, 2000) [26], vitamin C (Ranganna, 2009) [27] and T. phenol (Osorio-Esquivel, 2011) [28] were evaluated as well as the color parameters of fruit pulp (L^* , a^* , b^* , Chroma and Hue angle). The data were analyzed by SPSS software

(version 17) and Duncan multiple range tests with 5% were used.

Results and discussion

Table 1: Effects of Spirulina extracts and low temperatures on plant height, leaf number, leaf area, fresh and dry weight of cantaloupe plants

characters Treatments	Plant height (cm)		No. of leaves/plant		leaf area (cm ²)		Fresh weight/plant (g)		Dry weight/plant (g)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
NC × 0 (Control)	65.3 ^k	68.5 ^k	124.7 ^k	126.4 ^k	154.1 ^k	158.4 ^k	138.75 ^l	145 ^l	14.5 ^k	14.7 ^k
NC × 1.5	68.0 ^j	71.3 ^j	127.7 ^j	131.5 ^j	158.7 ^j	162.4 ^j	142.5 ^j	149.6 ^j	14.8 ^j	15.1 ^j
NC × 3	62.3 ^l	64.2 ^l	121.7 ^l	125.8 ^l	145.6 ^l	148.9 ^l	127.5 ^k	132.5 ^k	13.2 ^l	13.6 ^l
C1D × 0	84.7 ^h	86.2 ^h	152.7 ^h	153.0 ^h	162.4 ^h	165.3 ^h	144.2 ^h	152.3 ^h	15.8 ^h	16.2 ^h
C1D × 1.5	85.3 ^g	88.4 ^g	153.0 ^g	167.0 ^f	166.3 ^g	168.8 ^g	148.75 ^g	155 ^g	16.3 ^g	16.7 ^g
C1D × 3	70.0 ⁱ	73.3 ⁱ	131.3 ⁱ	142.0 ⁱ	159.6 ⁱ	163.7 ⁱ	141.8 ⁱ	148.3 ⁱ	15.1 ⁱ	15.7 ⁱ
C2D × 0	91.7 ^e	94.1 ^e	161.3 ^e	168.6 ^e	172.3 ^e	176.8 ^e	157.5 ^e	166.25 ^e	18.9 ^e	19.1 ^e
C2D × 1.5	93.6 ^d	97.1 ^d	168.3 ^d	177.4 ^d	176.3 ^d	179.7 ^d	170 ^d	173.75 ^d	19.7 ^d	19.9 ^d
C2D × 3	89.3 ^f	91.3 ^f	155.3 ^f	164.2 ^g	168.3 ^f	170.1 ^f	152.7 ^f	161.6 ^f	17.8 ^f	18.4 ^f
C3D × 0	96.0 ^b	99.5 ^b	175.7 ^b	183.1 ^b	181.2 ^b	185.4 ^b	173.2 ^b	177.5 ^b	20.9 ^b	21.2 ^b
C3D × 1.5	97.0 ^a	102.3 ^a	176.0 ^a	189.4 ^a	186.3 ^a	189.1 ^a	180 ^a	186.25 ^a	21.3 ^a	21.7 ^a
C3D × 3	95.8 ^c	98.4 ^c	174.7 ^c	179.3 ^c	178.1 ^c	182.2 ^c	171.2 ^c	174.6 ^c	20.1 ^c	20.7 ^c

NC= no cold/ C= cold/ C1D= cold 1 day/ C2D= cold 2 days/ C3D= cold 3 days/ 0= no spirulina/ 1.5= spray with 1.5 ml/ 1/ 3= spray with 3 ml/ 1 Means with the same letters within the same column no significantly different between means

1. Effects of Spirulina extracts and low temperatures on plant height, leaf number, leaf area, fresh and dry weight of cantaloupe plants

Increasing the duration of cooling for seeds resulted in improved vegetative growth of the cantaloupe plants in all three treatments, including increased plant height, number of leaves per plant, leaf area, and fresh and dry weight per plant, when compared to the control group (Table 1). When aqueous spirulina extract was applied to the plants as a foliar spray, the greatest improvement in vegetative growth was observed at a concentration of 1.5 ml of spirulina extract per 100 ml of water, compared to the control group. However, when the concentration was increased to 3 ml of spirulina extract per 100 ml of water, the vegetative growth was reduced. The use of spirulina extracts to enhance vegetative growth may be attributed to the presence of biostimulants that promote plant growth and development, such as trace elements, organic substances like amino acids, and plant growth regulators like auxin, cytokine, and gibberellins. These substances improve the nutritional status and overall vegetative growth of the plants, as previously

reported by Abd El-Moniem and Abd-Allah (2008) [8]. In addition, they mentioned that the promotion of algal extract was dependent on increasing its concentrations. However, it was found to be inconsequential when used at higher concentrations, such as those found in grapevines. Jensen (2004) [29] demonstrated that seaweed extract contains a variety of micro and macro elements, as well as hormones like Auxins, Gibberellins, and Cytokinins. When applied to plants, it improves root development, nutrient absorption, stem thickness, and overall vegetative and root growth. Seaweeds and their extracts also contribute to soil health by promoting the establishment of beneficial soil microorganisms and increasing moisture retention (Khan *et al.*, 2009) [30]. Several reports have been found to be consistent with our findings, such as the studies conducted by Sivasankari *et al.*, (2006) [31] and Abdel Mawgoud *et al.*, (2010) [19] on watermelon, as well as the research conducted by Mohammed (2013) [22], who discovered that spraying pepper with seaweed extract resulted in the highest average of vegetative growth.

Table 2: Effect of spirulina extracts and low temperature on the levels of chlorophyll a, b, and total chlorophyll in the leaves of a cantaloupe plant

Characters Treatments	Chl a mg.kg-1		Chl b mg.kg-1		Total Chl mg.kg-1	
	S1	S2	S1	S2	S1	S2
NC × 0 (Control)	1025 ^l	1032 ^l	788.46 ^l	812.60 ^l	1813.5 ^l	1844.6 ^l
NC × 1.5	1037 ^k	1058 ^k	797.69 ^k	833.07 ^k	1834.7 ^k	1891.1 ^k
NC × 3	1045 ^j	1065 ^j	803.85 ^j	838.58 ^j	1848.8 ^j	1903.6 ^j
C1D × 0	1070 ⁱ	1080 ⁱ	823.08 ⁱ	850.39 ⁱ	1893.1 ⁱ	1930.4 ⁱ
C1D × 1.5	1093 ^h	1112 ^h	840.77 ^h	875.59 ^h	1933.8 ^h	1987.6 ^h
C1D × 3	1120 ^g	1135 ^g	861.54 ^g	893.70 ^g	1981.5 ^g	2028.7 ^g
C2D × 0	1132 ^f	1152 ^f	870.77 ^f	907.09 ^f	2002.8 ^f	2059.1 ^f
C2D × 1.5	1162 ^e	1210 ^e	893.85 ^e	952.76 ^e	2055.8 ^e	2162.8 ^e
C2D × 3	1193 ^d	1232 ^d	917.69 ^d	970.08 ^d	2110.7 ^d	2202.1 ^d
C3D × 0	1265 ^c	1287 ^c	973.08 ^c	1013.39 ^c	2238.1 ^c	2300.4 ^c
C3D × 1.5	1360 ^b	1380 ^b	1046.15 ^b	1086.61 ^b	2406.2 ^b	2466.6 ^b
C3D × 3	1378 ^a	1420 ^a	1060.00 ^a	1118.11 ^a	2438.0 ^a	2538.1 ^a

NC= no cold/ C= cold/ C1D= cold 1 day/ C2D= cold 2 days/ C3D= cold 3 days/ 0= no spirulina/ 1.5= spray with 1.5 ml/ 1/ 3= spray with 3 ml/ 1

Means with the same letters within the same column no significantly different between means

2. Effect of spirulina extracts and low temperature on the levels of chlorophyll a, b, and total chlorophyll in the leaves of a cantaloupe plant

It was discovered that a combination of cooling the seeds for 3 days before planting and applying 1.5 ml concentrate spirulina extract per 100 ml of water led to the maximum growth in terms of plant height, number of leaves per plant, leaf area, and fresh and dry weight per plant, when compared to other treatments.

It is evident from Table 2 that increasing the concentration of spirulina foliar application tended to have the highest values for photosynthetic pigments. This effect was particularly noticeable when using the higher rate. Previous research by Schwab and Raab (2004) [32] has shown that seaweed extracts contain significant amounts of cytokinins, auxins, and betaines, which contribute to higher chlorophyll levels in leaves. Our findings align with earlier studies

conducted by Whapham *et al.*, (1993) [33], who observed that applying seaweed (*Ascophyllum nodosum*) increased chlorophyll levels in cucumber seedlings and tomato plants. Similarly, Blunden *et al.* (1996) [34] found that spraying seaweed extract enhanced chlorophyll levels in leaves. Thirumaran *et al.*, 2009 [35], showed that extracting seaweed from (*Cyamopsis tetragonoloba*) increased photosynthetic pigments such as chlorophyll a, b, total chlorophyll and carotenoids.

These results also showed that the increase in the cooling of subjected seeds increased the types of leaf chlorophyll in plants. C3D 3 treatments that act on the interaction between three-day cooling and use of 3mL/L of foliar spray of spirulina provide the maximum chlorophyll pigment that increases in second season compared to the first season, as shown in the Table.

Table 3: Effects of spirulina extracts and low temperatures on male and female flowers, fruit/plant numbers, and the first flowering time of cantaloupe plants.

Characters Treatments	Number of male flowers		Number of female flowers		Number of fruit/plant		First flowering time	
	S1	S2	S1	S2	S1	S2	S1	S2
NC × 0 (Control)	21.9 ^j	23.5 ^k	6.4 ^k	6.9 ^k	2.8 ^k	3.0 ^k	37.4 ^b	35.1 ^b
NC × 1.5	25.0 ⁱ	26.6 ^j	7.4 ^j	7.8 ^j	3.2 ^j	3.4 ^j	37.1 ^c	34.8 ^c
NC × 3	20.3 ^k	22.7 ^l	6.0 ^l	6.7 ^l	2.6 ^l	2.9 ^l	38.8 ^a	36.4 ^a
C1D × 0	28.2 ^g	30.5 ^h	8.3 ^h	9.0 ^h	3.6 ^h	3.9 ^h	36.2 ^e	34.4 ^e
C1D × 1.5	30.5 ^f	32.1 ^g	9.0 ^g	9.4 ^g	3.9 ^g	4.1 ^g	36.0 ^f	34.1 ^f
C1D × 3	25.8 ^h	27.4 ⁱ	7.6 ⁱ	8.1 ⁱ	3.3 ⁱ	3.5 ⁱ	37.0 ^d	35.0 ^d
C2D × 0	32.8 ^d	36.8 ^e	9.7 ^e	10.8 ^e	4.1 ^e	4.7 ^e	35.9 ^h	33.8 ^h
C2D × 1.5	32.8 ^d	37.5 ^d	9.7 ^d	11.0 ^d	4.2 ^d	4.8 ^d	35.4 ⁱ	33.4 ⁱ
C2D × 3	31.3 ^e	33.6 ^f	9.2 ^f	9.9 ^f	4.0 ^f	4.3 ^f	36.0 ^g	33.9 ^g
C3D × 0	36.0 ^b	43.0 ^b	10.6 ^b	12.7 ^b	4.6 ^b	5.5 ^b	35.4 ^k	32.6 ^k
C3D × 1.5	38.3 ^a	46.1 ^a	11.3 ^a	13.6 ^a	4.9 ^a	5.9 ^a	35.0 ^l	32.5 ^l
C3D × 3	34.4 ^c	40.7 ^c	10.1 ^c	12.0 ^c	4.4 ^c	5.2 ^c	35.8 ^j	33.8 ^j

NC= no cold/ C= cold/ C1D= cold 1 day/ C2D= cold 2 days/ C3D= cold 3 days/ 0= no spirulina/ 1.5= spray with 1.5 ml/ 1/ 3= spray with 3 ml/ l

Means with the same letters within the same column no significantly different between means

Table 4: Effect of spirulina extracts and low temperature on different yield parameters in cantaloupe fruits

Characters Treatments	Average fruit (g)		Total yield /plant kg		Total yield /plot kg		Total yield/fed.(ton)	
	S1	S2	S1	S2	S1	S2	S1	S2
NC × 0 (Control)	450 ^k	465 ^k	1.26 ^k	1.40 ^k	25.2 ^k	27.9 ^k	10.6 ^k	11.7 ^k
NC × 1.5	480 ^j	490 ^j	1.54 ^j	1.72 ^j	30.7 ^j	34.3 ^j	12.9 ^j	14.4 ^j
NC × 3	432 ^l	445 ^l	1.12 ^l	1.29 ^l	22.5 ^l	25.8 ^l	9.4 ^l	10.8 ^l
C1D × 0	510 ^h	535 ^h	1.84 ^h	2.09 ^h	36.7 ^h	41.7 ^h	15.4 ^h	17.5 ^h
C1D × 1.5	545 ^g	588 ^g	2.13 ^g	2.41 ^g	42.5 ^g	48.2 ^g	17.9 ^g	20.3 ^g
C1D × 3	500 ⁱ	515 ⁱ	1.65 ⁱ	1.75 ⁱ	33.0 ⁱ	35.0 ⁱ	13.9 ⁱ	14.7 ⁱ
C2D × 0	737 ^e	780 ^e	3.10 ^e	3.74 ^e	61.9 ^e	74.9 ^e	26.0 ^e	31.4 ^e
C2D × 1.5	820 ^d	843 ^d	3.61 ^d	4.38 ^d	72.2 ^d	87.7 ^d	30.3 ^d	36.8 ^d
C2D × 3	710 ^f	750 ^f	2.84 ^f	3.23 ^f	56.8 ^f	64.5 ^f	23.9 ^f	27.1 ^f
C3D × 0	1362 ^b	1470 ^b	6.27 ^b	8.09 ^b	125.3 ^b	161.7 ^b	52.6 ^b	67.9 ^b
C3D × 1.5	1480 ^a	1590 ^a	7.25 ^a	9.38 ^a	145.0 ^a	187.6 ^a	60.9 ^a	78.8 ^a
C3D × 3	1320 ^c	1400 ^c	5.54 ^c	6.58 ^c	110.9 ^c	131.6 ^c	46.6 ^c	55.3 ^c

NC= no cold/ C= cold/ C1D= cold 1 day/ C2D= cold 2 days/ C3D= cold 3 days/ 0= no spirulina/ 1.5= spray with 1.5 ml/ 1/ 3= spray with 3 ml/ l

Means with the same letters within the same column no significantly different between means

3. Effects of spirulina extracts and low temperatures on male and female flowers, fruit/plant numbers, and the first flowering time of cantaloupe plants

Based on the data presented in Table 3, it is evident that the number of female flowers increased when the seeds of cantaloupe were cooled for a longer period before agriculture. Additionally, the number of female flowers improved when sprayed with 1.5 ml concentrated spirulina

per liter compared to the control. However, spraying with 3 ml resulted in a decrease in female flowers number and fruit per plant, particularly during the first season. The percentage of flowers that reach maturity plays a crucial role in crop yield. It is noteworthy that the various treatments had substantial variances in terms of first flowering, as illustrated in Table 3. The earliest flowering occurs when the days of cooling are increased. The maximum earliest

flowering was observed after three days of cooling. When comparing it to the control, spraying spirulina extract spray with 1.5 ml concentrated spirulina per liter resulted in the earliest flowering, while using 3 ml concentrated spirulina per liter produced the latest flowering compared to the control. The earliest flowering was observed when there was an interaction between three days of cooling and spraying with 1.5 ml concentrated spirulina per liter, compared to other treatments. It can be assumed that the early flower set was triggered either by improved plant growth or possibly by some natural component in the product. Cytokinins, auxins, gibberellins, and ethylene have been found to have an impact on flowering (Bandurski and Nonhebel, 1984 [36]). Various groups of plant hormones are known to be present in seaweed extract. Applying seaweed extract to leaves during plant growth and before flowering has been shown to promote fruit development and increase yields through the action of hormones like cytokinin (Featonby-Smith and Van Staden, 1983a) [37]. It has been well documented that cytokinins play a role in the mobilization of nutrients in vegetative plant organs (Gersani and Kende, 1982) [38]. Additionally, high levels of cytokinins in reproductive organs (Summons *et al.*, 1980) [39] have been linked to this mobilization process (Wareing and Seth, 1967) [40]. As a result, ripening fruit has the potential to be more effective nutrient sinks (Varga and Bruinsma, 1974) [41], resulting in preferential movement throughout the growing plant (Hutton & Van Sta-den, 1984) [42]. Throughout fruit development, there is a shift in the mobilization center for photosynthates away from the young leaves, roots, and stem towards the developing fruit (Nooden and Leopold, 1978) [43]. Moreover, it is known that plants spraying with seaweed contain higher levels of cytokinins in the roots (Featonby-Smith, 1984) [44], supplying an enhanced source of cytokinins for delivery to the growing fruit.

The findings indicated a significant increase in the fruits number/plant with an extended period of cooling, particularly during the second season compared to the first season. Similarly, the aforementioned factors showed an increase when foliar spray at a concentration of 1.5 ml/l was applied, as opposed to the control treatment. However,

applying a foliar spray of 3 ml/l with spirulina resulted in a decrease in fruits per plant. The results are compatible with reported by Sarhan and Ismael (2014) [23] who found that the foliar sprays of seaweed extracts increased the amount of fruits produced per plant substantially.

4. Effect of spirulina extracts and low temperature on different yield parameters in cantaloupe fruits

Table 4 presents the results of a study that examined the effects of cooling seeds at 4°C before planting and applying a foliar spray with spirulina extract on the productivity of cantaloupe plants over two planting seasons. The findings suggest that there was a significant improvement in various features such as average fruit weight, total yield per plant, total yield per plot, and total yield per fed. with a longer period of cooling, especially during the second season compared to the first season. Similarly, when a foliar spray with a concentration of 1.5 ml/l was applied, these features also showed an increase compared to the control treatment. However, the application of a foliar spray of 3 ml/l with spirulina resulted in a decrease in all of the mentioned features. On the other hand, when combining the foliar spray at 1.5 ml/l with 3 days cooling period for seeds before agriculture, it was found to significantly enhance productivity, especially during the second season. This could be attributed to the utilization of spirulina extract as a biostimulant, which provides plants with essential micro and macronutrients, as well as significant amounts of cytokinins, auxins, and betaines. By increasing chlorophyll production and boosting the photosynthetic process, this biostimulant effectively stimulates vegetative growth.

The application of spirulina extract on plants has been shown to improve plant performance and increase productivity. Spraying tomato plants with seaweed extract in a greenhouse led to a rise of 17% in the total weight of fruit and a 10 percent rise for harvested fruit, according to (Blunden *et al.*, 1991[45]). Multiple researchers (Abd El-Moniem and Abd-Allah 2008 [8]; Shehata *et al.*, 2011) [21] have also reported similar findings, demonstrating that the use of seaweed extract can enhance yield characteristics in various plant species.

Table 5: Effect of spirulina extracts and low temperature on brix, pH, total acidity, vitamin C and total phenolic of fruits cantaloupe plant

Characters Treatments	Brix		pH		Total acidity		Vitamin C		T. Phenolic (mg/100g)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
NC × 0 (Control)	12.5 ^k	12.7 ^k	5.91 ^j	5.94 ^k	0.91 ^b	0.89 ^b	15.3 ^k	17.2 ^k	54.4 ^k	56.7 ^k
NC × 1.5	12.6 ^j	12.8 ^j	5.95 ⁱ	5.98 ^j	0.87 ^c	0.84 ^c	16.7 ^j	19.6 ^h	54.8 ^j	58.3 ^j
NC × 3	12.4 ^l	12.6 ^l	5.83 ^k	5.89 ^l	0.95 ^a	0.92 ^a	15.1 ^l	16.2 ^l	52.5 ^l	55.5 ^l
C1D × 0	12.8 ^h	13.1 ^h	5.97 ^s	6.03 ^h	0.89 ^d	0.85 ^d	18.3 ^h	19.2 ⁱ	57.3 ^h	60.1 ^h
C1D × 1.5	13.0 ^g	13.2 ^g	6.02 ^f	6.05 ^g	0.86 ^f	0.82 ^f	18.6 ^g	19.8 ^g	57.6 ^g	60.2 ^g
C1D × 3	12.7 ⁱ	12.9 ^j	5.95 ^h	5.99 ⁱ	0.90 ^c	0.88 ^c	17.8 ⁱ	17.4 ^j	56.6 ⁱ	59.7 ⁱ
C2D × 0	13.3 ^e	13.5 ^e	6.04 ^e	6.12 ^e	0.85 ^g	0.82 ^f	20.5 ^e	23.4 ^e	59.3 ^e	63.4 ^e
C2D × 1.5	13.4 ^d	13.6 ^d	6.13 ^d	6.13 ^d	0.82 ⁱ	0.79 ^g	23.6 ^d	26.7 ^d	59.7 ^d	64.1 ^d
C2D × 3	13.2 ^f	13.4 ^f	6.02 ^f	6.09 ^f	0.87 ^e	0.85 ^d	19.8 ^f	22.7 ^f	58.4 ^f	61.4 ^f
C3D × 0	13.8 ^b	14.4 ^b	6.15 ^b	6.21 ^b	0.82 ⁱ	0.75 ^h	28.4 ^b	36.5 ^b	61.2 ^b	66.1 ^b
C3D × 1.5	14.2 ^a	14.6 ^a	6.25 ^a	6.30 ^a	0.78 ^j	0.72 ⁱ	36.7 ^a	42.1 ^a	64.7 ^a	69.8 ^a
C3D × 3	13.5 ^c	14.0 ^c	6.12 ^c	6.19 ^c	0.84 ^h	0.79 ^g	27.4 ^c	30.4 ^c	60.1 ^c	65.3 ^c

NC= no cold/ C= cold/ C1D= cold 1 day/ C2D= cold 2 days/ C3D= cold 3 days/ 0= no spirulina/ 1.5= spray with 1.5 ml/ l/ 3= spray with 3 ml/ l

Means with the same letters within the same column no significantly different between means

Table 6: Effect of spirulina extracts and low temperature on color parameters of cantaloupe fruits pulp

Characters Treatments	L*		a*		b*		Chroma		Hue angle	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2

NC × 0 (Control)	65.2 ^k	68.3 ^k	-10.9 ^k	-10.4 ^k	10.6 ^k	10.9 ^k	15.2 ^f	15.1 ^f	45.5 ^k	46.3 ^k
NC × 1.5	67.1 ^g	70.6 ^j	-10.6 ^j	-10.2 ^j	10.9 ^j	11.2 ^j	15.2 ^f	15.1 ^f	46.9 ^j	47.7 ^j
NC × 3	64.5 ^l	66.4 ^l	-11.3 ^l	-10.8 ^l	10.3 ^l	10.6 ^l	15.3 ^e	15.1 ^f	43.6 ^l	44.5 ^l
C1D × 0	72.1 ^h	73.2 ^h	-9.8 ^h	-9.4 ^h	11.6 ^h	11.7 ^h	15.2 ^f	15.0 ^g	51.0 ^h	51.2 ^h
C1D × 1.5	72.5 ^g	73.4 ^g	-9.5 ^g	-9.1 ^g	11.9 ^g	12 ^g	15.2 ^f	15.1 ^f	52.6 ^g	52.8 ^g
C1D × 3	68.3 ⁱ	72.1 ⁱ	-10.1 ⁱ	-9.9 ⁱ	11.3 ⁱ	11.4 ⁱ	15.2 ^f	15.1 ^f	48.8 ⁱ	49.0 ⁱ
C2D × 0	73.3 ^e	76.2 ^e	-8.7 ^e	-8.4 ^e	12.7 ^e	12.8 ^e	15.4 ^d	15.3 ^e	56.5 ^e	56.7 ^e
C2D × 1.5	74.8 ^d	77.1 ^d	-8.5 ^d	-8.3 ^d	13.2 ^d	13.6 ^d	15.7 ^c	15.9 ^e	57.8 ^d	58.6 ^d
C2D × 3	72.8 ^f	74.3 ^f	-9.1 ^f	-8.8 ^f	12.3 ^f	12.7 ^f	15.3 ^e	15.5 ^d	54.4 ^f	55.3 ^f
C3D × 0	76.2 ^b	78.3 ^b	-7.8 ^b	-7.6 ^b	14.1 ^b	14.4 ^b	16.1 ^b	16.3 ^b	61.7 ^b	62.2 ^b
C3D × 1.5	78.3 ^a	78.8 ^a	-7.5 ^a	-7.1 ^a	14.7 ^a	14.9 ^a	16.5 ^a	16.5 ^a	64.2 ^a	64.5 ^a
C3D × 3	75.1 ^c	78 ^c	-8.1 ^c	-7.9 ^c	13.5 ^c	13.8 ^c	15.7 ^c	15.9 ^c	59.7 ^c	60.2 ^c

NC= no cold/ C= cold/ C1D= cold 1 day/ C2D= cold 2 days/ C3D= cold 3 days/ 0= no spirulina/ 1.5= spray with 1.5 ml/ l/ 3= spray with 3 ml/l

5. Effect of spirulina extracts and low temperature on brix, pH, total acidity, vitamin C and total phenolic of fruits cantaloupe plant

TSS showed an increase when a foliar spray of 1.5 ml/l of spirulina was applied, compared to the control treatment. However, increasing the concentration of the foliar spray to 3 ml/l resulted in a decrease in total soluble solids compared to the control. The application of spirulina during the second season significantly increased the brix values compared to the first season. Similar findings were reported by El-Aidy *et al.*, (2002) [46] when they applied seaweed extracts via foliar application on pepper plants. Abd El Moniem and Abd-Allah (2008) [8] also observed a significant increase in TSS when algal extract was sprayed on vines, compared to untreated vines. The enhancement of total soluble substances in fruits may be attributed to the positive influence of seaweed extracts on leaf area and the efficiency of the photosynthesis process (Jensen, 2004) [29]. The brix values were significantly increased by extending the period of cooling for seeds, as indicated by the findings. The highest brix values were achieved through the combination of a 1.5ml/l foliar spray and cooling seeds for 3 days, with values ranging between 14.2% and 14.6% during two agricultural seasons. In terms of pH and acidity, it was observed that a foliar spray of 1.5ml/l increased the pH value and decreased the acidity compared to the control. Abd El Moniem and Abd-Allah (2008) [8] discovered that using algal extract as a spray greatly enhanced the total acidity of treated vines when compared to untreated ones. Applying a foliar spray of 3ml/l resulted in a decrease in pH value and an increase in acidity compared to the control group. Additionally, cooling the seeds had a similar effect, causing an increase in pH value and a decrease in acidity, with the most significant changes occurring over a longer period of cooling. The application of C3D 1.5 treatment yielded the highest pH value and the lowest acidity, which had a positive impact on the overall quality of the fruits, as it enhanced their natural sweetness. Vitamin C and phenolic compounds are highly valuable antioxidant compounds that enhance the overall quality of fruits and extend their shelf life, protecting them from potential damage. The application of Spirulina at a concentration of 1.5 ml/L resulted in an increase in both vitamin C and total phenols, as compared to the control. However, when Spirulina was applied at a concentration of 3 ml/L, both vitamin C and total phenols showed a decrease. Similar results obtained Masny and Zurawicz (2004) [14] who found that treating plants with seaweed extracts increased total soluble solids, vitamin C of fruits and fresh weight. On the contrary, cooling the seeds especially with the high number of cooling days increased

the values of vitamin C and total phenols compared to the control treatment. Which shows the desired effect of both factors on the quality of the fruits, especially when the interaction between them at the level of 1.5 ml / liter spirulina and the use of cooling for seeds for a period of 3 days.

6. Effect of spirulina extracts and low temperature on color parameters of cantaloupe fruits pulp

The data presented in Table 6 indicates that cooling seeds before planting has a positive effect on the color of cantaloupe fruits. This effect is particularly noticeable with an increase in the number of days of cooling. By increasing the cooling period, the pulp of the fruits becomes more transparent and less green, shifting towards a yellow color. Additionally, the clarity of the color improves significantly after three days of cooling. The results clearly demonstrate that the color parameters are enhanced when using a spray of spirulina extract at a concentration of 1.5 ml/l compared to the control group. However, using a spray at a concentration of 3 ml/l actually decreases the color parameters. Overall, the combination of three days of seed cooling before planting and spraying with a concentration of 1.5 ml/l yields the best improvement in pulp color for cantaloupe fruits over two consecutive seasons, with the second season showing even better quality compared to the first season.

Conclusion

To improve cantaloupe plant flowering, growth, and yield as well as achieve a bigger yield earlier and reduce the duration of time needed for flowering, spray spirulina at specific times until it reaches 1.5 ml/liter; however, to improve by cooling seed alone, cooling seed for three days prior to transplanting at 4 C achieves that. The maximum improvement is obtained by the interaction between three days of cooling and foliar spraying with spirulina extract to 1.5 ml/liter. When compared to 1.5 mL/L, spraying spirulina at 3 mL/L reduced flowering, growth, and yield.

References

- 1 Robinson RW, Decker-Walters DS. Disease and nematodes. In Cucurbitaceae. Oxon, Wallingford, England: CAB International, 1997, 164–189.
- 2 Barten JHM, Scott MJW, Kedar N, Elkindy Y. “Low temperature induce rough blossom-end scarring for tomato fruit early flower development” J. Amer. Soc. Hort. Sci.,1992:117(2):298–303.
- 3 Oufir M, Legay S, Nicot N, Moer KV, Hoffmann L, Renaut J, Hausman JF, *et al.* “Gene expression in

- potato during cold exposure: Changes in carbohydrate and polyamine metabolisms”, *Plant Sci*,2008:175:839-852.
- 4 Foley ME, Anderson JV, Horvath DP. “The effect of temperature, photoperiod, and vernalization on regrowth and flowering competence in *Euphorbia esula* (Euphorbiaceae) crown buds”, *Botany*,2009:67:986-992.
 - 5 Tewari GSK, Manoj KS, Sharma YK. “Effect of low temperature on flowering response and biochemical changes during the process of floral induction in *Cucumis sativus*”, *Res. Environ. Life Sci*,2009:2(3):181-184.
 - 6 Hongyan QL, Zhao HL, Zhou L. “Carbohydrate metabolism in tomato (*Lycopersicon esculentum* Mill.) seedlings and yield and fruit quality as affected by low night temperature and subsequent recovery”, *African Journal of Biotechnology*,2011:10(30):5743-5749.
 - 7 Ahmed YM, Shalaby EA. Effect of different seaweed extracts and compost on vegetative growth, yield and fruit quality of cucumber. *J. Hortic. Sci. Orna. Plants*,2012:4:235-240.
 - 8 Abd El Moniem EA, Abd-Allah ASE. Effect of Green Alga Cells Extract as Foliar Spray on Vegetative Growth, Yield and Berries Quality of Superior Grapevines. *American-Eurasian J. Agric. & Environ. Sci.*,2008:4:427-433.
 - 9 Sathya ARN, Kanaga AP, Sankar BS, Jeeva C. Antioxidant properties of phlorotannins from brown seaweed *Cystoseira trinodis* (Forsska^o) C. Agardh. *Arabian Journal of Chemistry* 2013, 10, S2608-S2614.
 - Norrie J, and Keathley JP. Benefits of *Ascophyllum nodosum* marine-plant extract applications to 'Thompson seedless' grape production. (Proceedings of the Xth International Symposium on Plant Bioregulators in Fruit Production, 2005). *Acta Hort*,2006:727:243-247.
 - 10 Crouch IJ, Van Staden J. Commercial seaweed products as Biostimulants in horticulture *Journal of Home and Consumer Horticulture*,1994:1:19–76.
 - 11 Booth E, The manorial value of seaweed. *Botanica Marina.*,1965:8:138-143.
 - 12 Zhang X, Schmidt RE. “Hormonecontaining products’ impact on antioxidant status of tall fescue and creeping bentgrass subjected to drought”, *Crop Sci*,2000:40:1344–1349.
 - 13 Riley H. “Effects of Algal Fibre and Perlite on Physical Properties of Various Soils and on Potato Nutrition and Quality on a Gravelly Loam Soil in Southern Norway”, *Acta Agriculturae Scandinavica B*,2002:52(2-3):86-95.
 - 14 Masny AB, Zurawicz E. Effect of applications of Kelpak SL and Goremar BM 86, Preparation on Yield and Fruit Quality in Two Strawberry Cultivars *Research Institute of Pomology and Floriculture Pomologicazna*,2004:18:96-100.
 - 15 Blunden G, Paul PB. “The effect of aqueous seaweed extracts and kinetin on potato yields”, *Journal of the Science of food and Agriculture*,2006:28(2):535-543.
 - 16 Eris AH, Sirritepe O, Sirritepe N. “The effect of Seaweed (*Ascophyllum nodosum*) Extract on Yield and Quality Criteria in peppers”, *Acta Horticulturae. (ISHS)*,2008:412:733-737.
 - 17 Gajewski M, Katarzyna G, Bobruk J. The influence of Goëmar Goteo biostimulator on yield and quality of two Chinese cabbage cultivars. *Conf. of biostimulators in modern agriculture “vegetable crops*. Warsaw, 2008, 23-27.
 - 18 Al-Jebbouri MA, Musa A. Effect of humic acid and seaweed extracts on growth, flowering and yield of cucumber (*Cucumis Sativus* L.). M.Sc. Thesis, College of Agriculture, University of Tekrit, Ministry of Higher Education and Scientific Research, Republic of Iraq (in Arabic), 2009.
 - 19 Abdel-Mawgoud AM, Tantaway AS, Magda MK, Hafez HA, Habib M. Seaweed extract improves growth, yield and quality of different watermelon hybrids. *Res. J. Agric. Biol. Sci.*,2010:6(2):161-168.
 - 20 Sarhan TZ. “Effect of humic acid and seaweed extracts on growth and yield of potato plants (*Solanum tubersum* L) Desiree cv.”, *Mesopotamia J. of Agric*,2011:39(2):19-25.
 - 21 Shehata S, Heba M, Abdel-Azem S, Abou El-Yazied A, M El-Gizawy A. “Effect of Foliar Spraying with Amino Acids and Seaweed Extract on Growth Chemical Constitutes, Yield and its Quality of Celeric Plant”, *European J of Scientific Research*,2011:58(2):257-256.
 - 22 Mohammed GH. Effect of sea amino and ascorbic acid on growth, yield and fruits quality of pepper (*Capsicum annum* L). *Int. J. Pure Appl. Sci. Technol.*,2013:17(2):9-16.
 - 23 Sarhan and Ismael, 2014. Effect of Low Temperature Science Target Inc. www.sciencetarget.com Society-of-Instrument-and-Control-Engineers (SICE 2002), Osaka, Japan.
 - 24 Balloni W, Tomaselli L, Giovannetti L, Margheri MC. Fundamental biology of the genus *Spirulina*. In: Cantarelli, C., Ciferri, O., Florenzano, G., Kapsiotis, G., Materassi, R., Treccani, U., Eds. Finalized project Search for new protein sources and new food formulations”. *Conference Proceedings: Prospects of Spirulina cultivation in Italy*. National Research Council. Florence-Academia dei Georgofili, CNR, Tipografia Coppini, 1980, 49-82.
 - 25 Arnon DI. Copper enzymes in isolated chloroplasts polyphenol oxidase in (*Beta Vulgaris*). *Plant Physico.*,1949:24:1-15.
 - 26 AOAC. Official methods of analysis, 16th edn. Association of Official Analytical Chemists, Washington, 2000.
 - 27 Ranganna S. *Handbook of analysis and quality control for fruit and vegetable products*. Tata McGraw Hill, New Delhi 2009, 1112.
 - 28 Osorio-Esquivel OA, ´lvarez VB, Dorantes-A´lvarez L, Giusti MM. Phenolics, betacyanins and antioxidant activity in *Opuntia joconostle* fruits. *Food Res., Int*,2011:44:2160-2168. <https://doi.org/10.1016/j.foodres.2011.02.011>.
 - 29 Jensen E. Seaweed, factor fancy, From the Organic Broadcaster, Published by Moses the Midwest Organic and Sustainable Education, From the Broadcaster,2004:12(3):164-170.
 - 30 Khan W, Rayirath UP, Subramanian SE, Jithesh MN, Rayorath PW, Hodges DM, *et al*. Seaweed extracts as bio stimulus of plant growth and development. *J. Plant Growth Reg.*,2009:28:386–399.
 - 31 Sivasankari S, Venkatesalu V, Anantharajand M, Chandrasekaran M. Effect of seaweed extracts on the

- growth and biochemical constituents of *Vigna sinensis*. *Bioresource Technology*,2006:97:1745–1751.
- 32 Schwab W, Raab T. Developmental changes during strawberry fruit ripening and physico-chemical changes during postharvest storage. In: Dris, R., Jain,S.M. (Eds.), *Production Practices and Quality Assessment of Food Crops, 'Qualityhandling and Evaluation'*, vol. 3. Kluwer Academic Publishers, Netherlands, 2004, 341–369.
 - 33 Whapham CA, Blunden G, Jenkins T, Wankins SD. Significance of betaines in the increased chlorophyll content of plants treated with seaweed extract *Appl Phycology*,1993:5:231-234.
 - 34 Blunden G, Jenkins T, Liu Y. Enhanced leaf chlorophyll levels in plants treated with seaweed extract. *J Appl Phycol.*,1996:8:535–543.
 - 35 Thirumaran G, Arumugam M, Arumugam R, Anantharaman P. Effect of sea weed liquid fertilizer on growth and pigment concentration of *Cyamopsis tetragonolaba* L Taub. *AmEuras. J. Agron.*,2009:2(2):50-56.
 - 36 Bandurski RS, Nonhebel HM. Auxins. In Wilkins MB (ed.), *Advanced Plant Physiology*. Pitman Publishing Ltd., London, 1984, 1-20.
 - 37 Featonby-Smith BC, Van Staden J. The effect of seaweed concentrate and fertilizer on the growth of *Beta vul-garis*. *Z. Pflanzenphysiol.*,1983a:112: 155-162.
 - 38 Gersani M, Kende H. Studies on cytokinin- stimulated translocation in isolated bean leaves. *J. Plant Growth Regul.*,1982:1:161-171.
 - 39 Summons RE, Entsch B, Letham DS, Gollnow BI, Macleod JK. Metabolites of zeatin in sweetcom kernels: purification and identification using HPLC and chemical- ionisation mass spectrometry. *Plasma*,1980:147:422-434.
 - 40 Wareing PF, Seth AK. Ageing and senescence in the whole plant. *Symp. Soc. Exp. Biol.* 21: 543-548. Valencia *et al.*,2018-1967, 2. doi:10.20944/preprints201810.0553.v1.
 - 41 Varga A, Bruinsma J. The growth and ripening of tomato fruits at different levels of endogenous cytokinins. *J. hortic. Sci.*,1974:49:135-142.
 - 42 Hutton MJ, Van Staden J. Transport and metabolism of labelled zeatin applied to the stems of *Phaseolus vulgaris* at different stages of development. *Z. Pflanzenphysiol.*,1984:114:331-339.
 - 43 Nooden LD, Leopold AC. Phytohormones and the endogenous regulation of senescence and abscission. In Le-tham DS, Goodwin PB, Higgins TJ (eds), *Phytohormones and Related Compounds: A Comprehensive Treatise*. I. Elsevier/Holland, Amsterdam, 1978, 329-369.
 - 44 Featonby-Smith BC. Cytokinins in *Ecklonia maxima* and the effect of seaweed concentrate on plant growth. Pd.D. Thesis. University of Natal, Pietermaritzburg, 1984, 153.
 - 45 Blunden G. Agricultural uses of seaweeds and seaweed extracts. In: Guiry MD, Blunden G (eds) *Seaweed resources in Europe: uses and potential*. Wiley, Chicester, 1991, 65-81.
 - 46 El-Aidy F, El-Zawily AI, El-Sawy BI, Hamed EM. Effect of seaweed extracts on sweet pepper plants grown under protected cultivation, 2ndInter. Conf Hort. Sci., 2002, 10–12 Sept., Kafr El-Sheikh, Tanta Univ., Egypt.