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Effect of Low Temperature and Seaweed Extracts on Flowering and Yield of Two Cucumber Cultivars (*Cucumis sativus* L.)

Taha Z. Sarhan* **and Salih Farhan Ismael**

Horticulture Department, Faculty of Agriculture and Forestry/ University of Duhok/ Iraq

Abstract

The experiment was conducted in a plastic house of the vegetable research field Horticulture Department, College of Agriculture, University of Dohuk, Iraq, to study the effect of seaweed extracts (seaforce and seamino) with concentrations (0.0, 1.5ml/L) for both extracts and exposure to low temperature (7±1)^{o}C for three durations (0, 5 and 10) days on the flowering and yield of two cucumber (*Cucumis sativus* L.) cultivars. The extracts were sprayed three times on seven days intervals. Seeds were sown on February 22th, 2011. The seedlings were exposed to low temperature after expansion of cotyledon leaves. The experiment was arranged in a factorial experiment within split-split plot in a randomized complete block design with four replicates. The results showed that treatment with both extracts significantly enhanced number of female flowers and fruit setting percentage. The dual interaction between factors (seaforce + seamino) + cultivar and (seaforce + seamino) + temperature exposure for (5) days were significant on flowering characters. The triple interaction (seaforce + seamino) + low temperature exposure for (5) days + Karol cultivar increased flowering characters, and for yield characters its showed that (seaforce + seamino) significantly increased cucumber yield (number of fruit per plant, fruit weight, yield per plant, yield.m^{2}and total yield).

Key words: *seaweed, temperature, Cucumber, cultivar*.

1. Introduction

Cucumber (*Cucumis sativus* L.) is one of the oldest vegetables and an important member of the Cucurbitaceae family. It is planted for its fruits, which is considered as a good source of minerals and vitamins. The crop is originated in India in an area located between Bay of Bengal and Himalaya mountains. It is one of the four major food crops of cucurbitaceae family, which includes watermelon, cucumber, melon and squash (Robinson and Decker-Walters, 1997). Cucumber is a warm season, annual, vining plant with laterals and tendrils. It is commonly cultivated in Iraq during the summer and fall seasons as well as in low tunnel and plastic houses. Its fruits are usually used freshly or after processing (Matlob et al., 1989).

The enhanced plant resistance to diseases provided by seaweed extracts is due to the antimicrobial activity of seaweeds against bacteria, yeast, and moulds, whereas, the increased plant growth, yield and quality is resulted from the influence of these extracts on cell metabolism via the induction of the synthesis of antioxidant molecules which could improve plant growth and plant resistance to stress (Zhang and Schmidt, 2000). These reports reveal that organic compounds rather than mineral elements are responsible for these effects. The importance of temperature for cucumber plant growth and its productivity is evident when cucumber seedlings are exposed to low temperatures, which stimulates

* Corresponding author: t_sarhan@yahoo.com

the plant to initiate flowers earlier and increases flowers' number by controlling the temperature where cucumber seedlings are exposed during sensitive flowering stage. The sensitive stage to low temperature is commenced after widening of cotyledon leaf, which continue for (10-14) days and during this stage the stem orientation is limited to produce flower clusters so increasing the number of flowers (Barten et al., 1992). Riley (2002) found that there was a significant increase (30-70%) in yield of potato by soil treatment with the seaweed extract Algal fibre at level (20 and 40 kg/hectare). Masny et al. (2004) found that using the seaweed (Geomar BM 80) with two concentration (0, 0.1) $ml.l^{-1}$ on two varieties (Salut, Elkat) of strawberry significantly increased the plant's qualitative characters such as total soluble solids and vitamins (C). In a study conducted by Blunden and Paul (2006) who sprayed two potato cultivars (King Edward and Pentlanddell) with seaweed extracts, they found that there was a significant increase in total yield. Treating pepper cultivar California Wonder with the seaweed extract *(Ascophyllum nodosum*) resulted in bigger fruit size (Eris et al., 2008). Gajewski et al. (2008) demonstrated that application of Geteo (an organicmineral fertilizer containing algae extract *Ascophyllum nodosum* with addition of phosphorus) significantly increased yield, marketable heads as well as vitamin C content of two cultivars of chinese cabbage. Al-Jebbouri (2009) stated that spraying cucumber plants with the seaweed extract seaforce1 significantly influenced number of male and female flowers, sex expression ratio and ultimately the total yield of the crop. Sarhan (2011) conducted an experiment to study the effect of humic acid and two seaweed extracts Alga 600 and seaforce 2 on potato plants. The results showed a positive significant effect of humic acid and seaweed extracts and their interactions on yield quantitative characters. Shehata et al. (2011) carried out an experiment in two successive winter seasons to investigate the influence of biostimulants seaweed extracts and amino acids in growth, chemical composition, yield and its quality plant. Results indicated that spraying plants with seaweed extracts significantly increased root yield whereas spraying with seaweed extract and amino acid increased the total sugar content. Temperature stresses exhibited by plants fit into three types: those occurring at (*a*) temperatures below freezing, (*b*) high temperatures (*c*) and low temperatures above freezing (KohaIba 2002). Low temperature is considered as one of the most critical abiotic stresses for plant growth, yielding and energy distribution (Xiong et al., 2002; Oufir et al., 2008). It affects translocation of photosynthetic products and carbohydrate metabolism and then affects plant growth and development, yield and fruit quality (Hongyan et al., 2011). Suh et al. (1996) studied the effect of exposure to low temperatures and short days on growth and yield of strawberry. The results showed that low temperature stimulated flowering and harvesting, but marketable yields were low because of small fruit size. Korkmaz and Dufault (2004) conducted a study for two years attempting to produce earliest yield of spring melon by transplanting field muskmelon in late winter before the last frost time. The "Athena" *Cucumis melo* L. muskmelon seedlings (were exposed to 2±1 °C then to 29±5 with various exposure durations before being transplanted in the field. The results indicated that in both years, increasing duration and frequency of stress significantly retarded muskmelon flowering and decreased yields. Tewari et al. (2009) reported that exposing cucumber seeds Variety Jyoti Green long to low temperature (4^0C) for (0, 24, 48 and 72 hours) and then allowing to germinate and grow under normal conditions for two weeks had a profound effect on the flowering response in cucumber. Foley et al. (2009) reported that exposing the herbaceous weed *euphorbia esula* L. to gradually decreased temperatures resulted in rapid re-growth and flowering.

2. Materials and Methods

The experiment was conducted in a plastic house (500 m^2), its width was 10m and its length was 50m, provided with a drip irrigation system which consisted of ten perforated houses of 50m length each. The experiment consisted of exposing of cucumber (*Cucumis sativus* L.) seedlings to low temperatures 7±1^{o}C after cotyledon expansion stage for three times (5 and 10 days in addition to controls), and application of Seaweed extracts at four levels (E_o control, E1 spray with 1.5 ml/L. of seaforce, E2 spray with 1.5 ml/L of seamino, E3 spray with a mixture of 1.5 ml/L + 1.5 ml/L of the two extracts seaforce and seamino). The two seaweed extracts (seamino and seaforce) concentrations were prepared by mixing 1.5 ml of each extract with one liter of tap water. The treatments were arranged in a factorial Randomized Complete Block Design within split-split plot system. The main plot was represented by two cucumber cultivars and the subplot was represented by low temperature and the sub-sub plot was represented by concentrations of two seaweed extracts. Therefore, the experiment comprised of three factors; the first factor was two cucumber cultivars (Karol and Reem), the second factor was exposing cucumber seedlings to low temperature 7±1^{o}C for three times (0, 5 and 10 days) and the third factor was two seaweed extracts (seaforce and seamino) applied at two concentrations (0.0, 1.5 ml) for both. So, the trial included 24 treatments (2 × 3 × 4), each treatment was replicated three times and each replicate was represented by four lines, each line was (3m^2) of 10 plants, with 30 cm intra space between plants. The results were analyzed by (SAS, 2007) program and Duncan multiple range test at 5% was used. The average of maximum and minimum temperature and relative humidity inside the plastic house during the study season had been recorded as in Table 1.

Table 1

Average of maximum and minimum temperatures and relative humidity inside the plastic house during the study season (2011)

Month	Temperature(ºC)		Relative Humidity
	Max.	Min.	
March	24	8	40
April	28.3	10	42.8
May	37.4	15.3	35.7
June	40.6	22.8	32.9
July	45.2	25.9	30.6

Temperature was measured by thermohydrograph instrument.

The soil of plastic house was sandy clay loam. Several samples were taken randomly from different sites inside the plastic house at the depth of (30 cm). The samples were air dried and then sieved using 2.0 mm sieve for analysis of some chemical and physical properties of the soil as illustrated in Table 2.

Table 2

Some physical and chemical characteristics of the plastic house soil

Characteristics	Measuring units	2011
Volumetric distribution of soil separate		
Sand	(%)	50.9
Silt	(%)	22.5
Clay	(%)	26.6
Texture	---	Sandy clay loam
Available nutrient content		
Total –N	(%)	1.652
Available phosphorus	(%)	0.0297
Available potassium	ppm	1.461
Organic matter	(%)	1.942
pH	1:1 in peste	7.04
Electrical conductivity	(ds.m^{-1})	0.178

The analysis was carried out at soil and water science laboratory, College of Agriculture, Duhok University.

The plastic house area was divided into ten lines according to the arrangement of the drip irrigation system. Each line consisted of 12 parts and was divided into a line of 3m^2. The area was well irrigated and the doors were kept closed for a few days for good disinfection. Cucumber seeds of two gynoecious indeterminate cultivars ; Reem and Karol were sown in culturing trays previously filled with sowing media two seeds per gap on 22 of February, 2011, then the plates were transferred to the greenhouse. The field was drip irrigated before planting. All seedlings were planted on March, 12th 2011 at a distance of 30 cm between plants along the perforated nozel line of drip irrigation system, each seedling was at the water hole. Other cultural operations including weeding, soil softening around transplants and protective spraying were also carried out for each experimental unit. Plants were trained on wires letting the main shoot apex to grow upwards towards the wire and then dangle downwards with removal of lateral shoots.

Table 3

Effect of seaweed extracts, low temperature and their interaction on date till 1st female flower initiation of cucumber Karol and Reem cultivars

Cultivars	Seaweed Extracts	Concentration ml/L	Exposure to low temperature 0 days	5 days	10 days	Seaweeds x cultivars
Reem	0	0	43.67a	36.33d-f	35.34ef	38.44a
	Seaforce	1.5	38.34bc	35.33ef	35.33ef	36.33ab
	Seamino	1.5	37.33sd	35.00fg	36.67de	36.33ab
	Seaforce x seamino	1.5	35.67ef	32.66h	33.67gh	34.00b
Karol	0	0	44.67a	36.00d-f	35.00fg	38.56a
	Seaforce	1.5	38.67b	35.00fg	36.00d-f	36.56ab
	Seamino	1.5	38.33bc	36.33d-f	35.00fg	36.56ab
	Seaforce x seamino	1.5	36.33ef	33.67gh	33.67gh	34.22b
						Mean effect of seaweeds
Seaweeds x temperature	0	0	44.17a	36.17c	35.17c	38.50a
	seaforce	1.5	38.50b	35.17c	35.67c	36.44b
	seamino	1.5	37.83b	35.67c	35.83c	36.44b
	Seaforce x seamino	1.5	35.50c	33.17d	33.67d	34.11c
						Mean effect of cultivars
Cultivars x temperature		Reem	38.75a	36.83b	35.25b	36.47a
		Karol	39.25a	35.25b	34.92b	36.28a
Mean effect of temperature			39.00a	35.04b	35.08b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level.

Experimental Measurements

a) Flowering Characteristics

Number of Nodes till First Female Flower Initiation

It was enumerated at the first female flower initiation for four plants from each experimental unit.

Number of Female Flowers

They were accounted from the beginning of their emergence during the growing season for four plants in each experimental unit.

Percentage of Fruit Setting

The fruit setting percentage was determined by calculating the total number of female flowers and the number of setting flowers for each plant in the experimental unit.

b) Yield Measurements

Number of Fruit per Plant^{-1}

The number of fruit per plant was accounted from four plants in each experimental unit starting from the first harvest and continuing till the end of the growing season (25 harvests) and then being calculated.

Average Weight of Fruit (g)

The average weight of fruit was measured by weighting the yield of each experimental unit at each harvest then it was divided by the fruit number in each experimental unit and multiplied by one thousand (1000).

Plant Yield (kg.plant^{-1})

Plant yield was measured by calculating the total yield of experimental unit and the number of plants in the experimental unit

Yield (kg.m^{2})

It was obtained by calculating the yield of experimental unit and the area of experimental unit.

Table 4

Effect of seaweed extracts, low temperature, and their interactions on number of Female Flower.Plant^{-1} of cucumber Karol and Reem cultivars

Cultivars	Seaweed Extracts	Concentration ml/L	Exposure to low temperature 0 days	5 days	10 days	Seaweeds x cultivars
Reem	0	0	42.91d-h	39.90g-i	35.44j	39.42c
	Seaforce	1.5	47.14bc	45.05c-e	40.89f-i	44.36ab
	Seamino	1.5	42.17d-i	38.36ij	46.23cd	42.25bc
	Seaforce x seamino	1.5	50.49ab	45.92cd	42.61d-h	46.34a
Karol	0	0	44.19c-f	41.37e-i	39.46hi	41.67bc
	Seaforce	1.5	43.26c-h	44.00cf	42.61d-h	46.34a
	Seamino	1.5	43.71c-g	45.22c-f	44.51c-f	44.48ab
	Seaforce x seamino	1.5	43.12c-h	51.25a	43.10c-h	45.82a
						Mean effect of seaweeds
Seaweeds x temperature	0	0	43.55b-d	40.63de	37.45e	40.54c
	seaforce	1.5	45.20a-c	44.52b-c	41.75c-d	43.82b
	seamino	1.5	42.94cd	41.79cd	45.37a-c	43.37b
	Seaforce x seamino	1.5	46.81ab	48.58a	42.85cd	46.08a
						Mean effect of cultivars
Cultivars x temperature		Reem	45.68a	42.31bc	41.29c	43.09a
		Karol	43.57a-c	45.46ab	42.42bc	43.21a
Mean effect of temperature			44.62a	43.88a	41.85b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level

Total Yield (ton.ha^{-1})

The total yield was accounted from each experimental unit from the beginning of harvest till the end of the growing season.

3. Results

Flowering Characteristics

Date Till 1st Female Flower Initiation: Seaweed extracts decreased the number of days to first female flower initiation and the higher number of days was recorded for control (38.50 days). Effect of exposure to low temperature on the date of 1st Female Flower Initiation resembled that of seaweed extracts and control plants possessed the highest number of days to 1st Female Flower Initiation (39.00 days). No significant differences occurred between date of 1st Female Flower Initiation for both Reem and Karol cultivars. The dual interaction between seaweed extracts and cultivars depressed the number of days to 1st Female Flower Initiation, and the highest number of days was measured for control plants from Reem (38.44 days) and Karol (38.56 days) cultivars as compared with plants treated with seaweed extracts. Cultivars x temperatures interaction significantly suppressed number of days till 1st Female Flower Initiation and the highest values owned by control plants (38.75, 39.25 days) for Reem and Karol cultivars respectively.

Number of Female Flower.Plant^{-1}: Significant differences were found according to seaweed extracts treatment. Application of both extracts (seaforce and seamino) gave the highest number of female flowers (46.08) (Table 4). Female flowers were also significantly increased in the control plants (44.62) as compared with low temperature treatments. Reem cultivar and Karol cultivar were not significantly different from each other in term of female flower number. In Table 5, it is conspicuous that (seaweeds x temperature) interaction significantly enhanced number of female flowers when plants received (seaforce + seamino) and were exposed to low temperature for 5 days (48.58) as compared with control and other treatments. No significant effect on female flower number was caused by (cultivar x temperature) interaction and the unexposed plants had the highest number of female flower (45.68). Contrary to the previous interaction, (cultivar x seaweeds) interaction significantly influenced the number of female flowers of both cultivars, and the highest value of flower number was from application of the two extracts seaforce and seamino in Reem cultivar (46.34).

Percentage of Fruit Setting: Table 5 showed that foliar application of both seaweed extracts (sea-force and seamino) significantly ameliorated percentage of fruit setting with no significant differences between plants that received both extracts and plants that were treated with each extract alone. However, higher fruit percentage was exhibited by spraying both extracts (83.47%). In case of temperature effect, it had no significant influence on fruit setting percentage, and control plants set higher fruits percentage(82.88%) than plants exposed to low temperature for a duration of 5 and 10 days (81.58, 80.12)%. Like temperature effect, no significant differences were noticed between fruit setting percentage of Reem and Karol cultivars. Regarding interaction between factors, (seaweeds x temperature) interaction was significant at treating plant with both extracts (seaforce + seamino) and exposing them to low temperature for 5 days (85.39%) (Table 6), and the Excellency was for spraying plants from Karol cultivar with seaforce and seamino 84.18%. Results in Table 6 indicated that (cultivar x seaweeds x temperature) interaction influenced Karol cultivar more than Reem cultivar. The maximum fruit setting percentage was for plants of Karol cultivar receiving (seaforce + seamino) and treated with low temperature for 5 days 86.39%.

Table 5

Effect of seaweed extracts, low temperature, and their interactions on fruit setting (%) of cucumber Karol and Reem cultivars

Cultivars	Seaweed Extracts	Concentration ml/L	Exposure to low temperature 0 days	5 days	10 days	Seaweeds x cultivars
Reem	0	0	80.38a-d	77.41c-e	73.75e	77.18
	Seaforce	1.5	82.38a-c	80.52a-d	85.57a	82.82a
	Seamino	1.5	81.89a-d	81.91a-d	80.56a-d	81.45ab
	Seaforce x seamino	1.5	82.77a-c	84.39ab	81.11a-d	82.76a
Karol	0	0	82.43a-c	78.47b-e	75.71de	78.87bc
	Seaforce	1.5	84.76ab	81.27a-d	81.66a-d	82.56a
	Seamino	1.5	69.98a-c	82.27a-c	81.87a-d	82.37a
	Seaforce x seamino	1.5	85.44a	86.39a	80.72a-d	84.18a
						Mean effect of seaweeds
Seaweeds x temperature	0	0	81.40a-c	77.94cd	74.73d	78.02b
	seaforce	1.5	83.57ab	80.89bc	83.61ab	82.69a
	seamino	1.5	82.44ab	82.09ab	81.22bc	81.91a
	Seaforce x seamino	1.5	84.11ab	85.39a	80.91bc	83.47a
						Mean effect of cultivars
Cultivars x temperature		Reem	81.86ab	81.06ab	80.25b	81.05a
		Karol	83.90a	82.10ab	79.99b	82.00a
Mean effect of temperature			82.88a	81.58ab	80.12b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan’s multiple range test at 5% level

Table 6

Effect of seaweed extracts, low temperature and their interaction on number of fruit per plant of cucumber Karol and Reem cultivars

Cultivars	Seaweed Extracts	Concentration ml/L	Exposure to low temperature 0 days	5 days	10 days	Seaweeds x cultivars
Reem	0	0	39.50c-f	30.99gf	26.18h	30.55d
	Seaforce	1.5	38.85bc	36.33cd	35.01c-f	36.73ab
	Seamino	1.5	34.54c-f	31.44e-g	37.25c	34.41bc
	Seaforce x seamino	1.5	41.72ab	38.78bc	34.54c-f	38.35a
Karol	0	0	36.40cd	32.50d-g	29.96g-h	32.96cd
	Seaforce	1.5	36.62cd	35.80c-e	34.86c-f	35.76a-c
	Seamino	1.5	36.28cd	37.19c	36.50cd	36.65ab
	Seaforce x seamino	1.5	36.89cd	44.27a	34.77c-f	38.64a
						Mean effect of seaweeds
Seaweeds x temperature	0	0	35.45c	31.74d	28.07e	31.75c
	seaforce	1.5	37.74bc	36.06bc	34.93dc	36.24b
	seamino	1.5	35.41c	34.31cd	36.87bc	35.53b
	Seaforce x seamino	1.5	39.13ab	41.52a	34.66cd	38.49a
						Mean effect of cultivars
Cultivars x temperature		Reem	37.40a	34.38ab	33.24b	35.01a
		Karol	36.55ab	37.44a	34.02ab	36.00a
Mean effect of temperature			39.98a	35.91a	33.63b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level

Yield Measurements

Number of Fruit.Plant^{-1}: The foliar sprays of seaweed extracts significantly enhanced number of fruits per plant. The highest number of fruits was produced by plants treated with both extracts (seaforce + seamino) (38.49). Temperature did not significantly increase fruit number when plants were exposed to low temperature for 5 days. However, control plants produced more fruits (38.98). In case of cultivars, concerning fruit number per plant, no significant difference was observed between Karol and Reem cultivars. The best interaction between seaweeds and temperature occurred from spraying plants with the two seaweed extracts and exposing them to low temperature for a duration of 5 days that resulted in higher number of fruits (41.52) as compared with control, plants treated with each extract alone and plants exposed for 10 days. Regarding Interaction between the three factors (cultivar x seaweeds x temperature), the fruit number was greatly affected in Karol cultivar compared to Reem cultivar, which did not significantly influence, and the highest fruit number (44.27) was obtained from plants of Karol cultivar that received both extracts (seaforce + seamino) and were exposed to low temperature for 5 days as compared with Reem cultivar and other treatments (Table 6).

Fruit Weight (gm): It can be seen in Table 7 that significant differences in fruit weight occurred between plants treated with seaweed extracts and untreated plants. Fruit weight was increased when plants were treated with both seaweed extracts (seaforce +seamino). On the other hand, exposure to low temperature did not significantly enhance fruit weight; control plants possessed the higher fruit weight (151.72 gm). Associated with cultivar effect, Reem cultivar was not significantly different from Karol cultivar in terms of fruit weight. Interaction between cultivars and seaweed extracts significantly improved fruit weight in both cultivars plants that were treated with (seaforce + seamino) which gave 156.55 and 156.98 gm for Reem and Karol cultivars respectively. On contrary, no significant differences were observed in fruit weight of both cultivars plants (Karol cultivar and Reem cultivar) due to (seaweeds x temperature) interaction. Similarly, the effect of interaction between the cultivar factor and the temperature factor was not significant on fruit weight in both cultivars.

Yield kg.Plant^{-1}: Application of seaweed extracts caused a significant improvement in yield per plant. Higher yield 6.04 kg was obtained from plants sprayed with both seaweed extracts (seaforce + seamino). Concerning temperature effect, exposure for 5 days enhanced yield per plant 5.39 kg, despite that the control plants produced slightly higher yield 5.49 kg. In term of cultivar effect, the majority was for Karol cultivar yielding 5.48 kg more than Reem cultivar.

Table 8 indicated that highest interaction between seaweeds and temperature was from applying (seaforce + seamino) and exposing plants to low temperature for 5 days recording 6.49 kg. A specific interaction was observed between cultivar and temperature too. Plants from Karol cultivar that were subjected to low temperature for 5 days produced higher yield 5.71 kg in comparison with Reem cultivar and other treatments. Also (seaweeds x cultivar) interaction caused a significant difference in yield per plant of the two cultivars. Both cultivar plants that were treated with (seaforce + seamino) extracts yielded higher 6.01, 6.07 kg than control plants and plants that were treated with each extract separately.

Plant Yield kg.m^{-2}: Data represented effect of seaweed extracts Table 9 showed that seaweed extracts had a significant influence on yield kg.m^{-2} as compared with control. Higher yield 15.13 kg.m^{-2} was produced by plants receiving (seaforce + seamino). In contrast, no significant differences were found in yield (kg.m^{-2}) of plants exposed to low temperature and control plants significantly differed from exposed plants and had the maximum yield 14.06 kg.m^{-2}. Karol cultivar was superior to Reem cultivar and gave higher yield 13.72 kg.m^{-2}. Regarding binary interactions, effect (seaweeds x temperature) interaction was significant on plant yield kg.m^{2}.

Table 7

Effect of seaweed extracts, low temperature and their interactions on fruit weight (g) of cucumber Karol and Reem cultivars

Cultivars	Seaweed Extracts	Concentration ml/L	Exposure to low temperature 0 days	5 days	10 days	Seaweeds x cultivars
Reem	0	0	134.71h	136.16h	139.63gh	136.83e
	Seaforce	1.5	147.74e-g	145.49g-f	148.56d-f	147.26cd
	Seamino	1.5	152.83b-f	156.07a-e	150.68d-f	153.19ab
	Seaforce x seamino	1.5	161.02ab	152.54b-f	156.08a-e	156.55a
Karol	0	0	150.70d-f	145.66gf	139.99gh	145.45d
	Seaforce	1.5	150.83d-f	152.04gf	148.68d-f	150.52bc
	Seamino	1.5	161.71a	150.94d-f	150.88d-f	154.51ab
	Seaforce x seamino	1.5	154.25a-f	159.83a-c	156.86a-d	156.98a
						Mean effect of seaweeds
Seaweeds x temperature	0	0	142.70de	140.91e	139.81e	141.14d
	seaforce	1.5	149.29b-d	148.76cd	148.62cd	148.89c
	seamino	1.5	157.27a	153.50a-c	150.78a-c	153.85b
	Seaforce x seamino	1.5	157.63a	156.18ab	156.47ab	156.76a
						Mean effect of cultivars
Cultivars x temperature		Reem	149.08a	147.56a	148.74a	148.46a
		Karol	153.37a	152.11a	149.10a	151.86a
Mean effect of temperature			151.72a	149.84ab	148.92b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level

Table 8

Effect of seaweed extracts, low temperature and their interactions on yield $kg.plant^{-1}$ of cucumber Karol and Reem cultivars

Cultivars	Seaweed Extracts	Concentration ml/L	Exposure to low temperature 0 days	5 days	10 days	Seaweeds x cultivars
Reem	0	0	4.15ef	4.21ef	3.65f	4.00d
	Seaforce	1.5	5.23b-d	5.27b-d	5.19b-d	5.23bc
	Seamino	1.5	5.28b-d	4.91cd	5.61bc	5.26bc
	Seaforce x seamino	1.5	6.71a	5.91b	5.39b-d	6.01a
Karol	0	0	5.48bc	4.74de	4.20ef	4.80c
	Seaforce	1.5	5.53bc	5.43b-d	5.18b-d	5.38b
	Seamino	1.5	5.86b	5.61bc	5.51bc	5.66ab
	Seaforce x seamino	1.5	5.69b	7.07a	5.46bc	6.07a
						Mean effect of seaweeds
Seaweeds x temperature	0	0	4.82cd	4.47de	3.92e	4.40c
	seaforce	1.5	5.38bc	5.35bc	5.19bc	5.30b
	seamino	1.5	5.57b	5.26bc	5.56b	5.46b
	Seaforce x seamino	1.5	6.20a	6.49a	5.43bc	6.04a
						Mean effect of cultivars
Cultivars x temperature		Reem	5.34ab	5.08ab	4.92b	5.13b
		Karol	5.64ab	5.71a	5.08ab	5.48a
Mean effect of temperature			5.49a	5.39a	5.02b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level

Plants treated with (seaforce + seamino) and subjected to low temperature for 5 days produced the highest yield 16.25 $kg.m^{-2}$. The same was true for (cultivar x temperature) interaction in Karol cultivar plants that received the same treatments (seaforce + seamino and were exposed to low temperature for 5 days had the highest yield 14.29 $kg.m^{-2}$. Interaction between cultivar, seaweeds and temperature significantly influenced Karol cultivar more than its counterpart Reem cultivar and this can be seen in Table 9. Perfect interaction took place between Karol cultivar with application of (seaforce + seamino) and low temperature exposure for 5 days resulting in the highest yield 17.70 $kg.m^{-2}$ as compared with Reem cultivar, control and other treatment (Table 9).

Total Yield $ton.Hectar^{-1}$: Total yield was significantly affected by seaweed extracts treatment. Application of seaforce extract and seamino extract together gave the highest total yield per hectare 133.21 ton, whereas the lowest total yield 98.88 ton was measured for control plants. Total yield was not influenced by low temperature exposure, and the control plants produced more total yield 123.73 ton. Vice versa was true for cultivar mean effect, Karol cultivar was distinguished from Reem cultivar by having higher total yield 120.78 ton (Table 10). Interaction between cultivar and temperature caused an increase in total yield of Karol plants when they were exposed to low temperature for 5 days as compared with Reem cultivar plants and other treatments. Significant differences were also observed in total yield due to (cultivar x seaweeds) interaction in both cultivars. Spraying plants with both extracts (seaforce + seamino) resulted in higher yield per hectare with 134.13 ton for Karol cultivar and 132.30 ton for Reem cultivar. In Reem cultivar, triple interaction (cultivar x seaweeds x temperature) significantly impacted total yield in Karol cultivar which produced the highest total yield 155.78 ton in plants which received (seaforce + seamino) and were exposed to low temperature for 5 days (Table 10).

Table 9

Effect of seaweed extracts, low temperature and their interactions on yield kg.m^2 of cucumber Karol and Reem cultivar

Cultivars	Seaweed Extracts	Concentration ml/L	Exposure to low temperature 0 days	5 days	10 days	Seaweeds x cultivars
Reem	0	0	11.63fg	10.56gh	9.13h	10.44d
	Seaforce	1.5	14.34bc	13.20b-f	13.00b-f	13.51b
	Seamino	1.5	13.22b-f	12.28d-f	14.04b-d	13.18bc
	Seaforce x seamino	1.5	16.80a	14.80b	13.50b-e	15.03a
Karol	0	0	13.72b-d	11.85f-g	10.51gh	12.02c
	Seaforce	1.5	13.83b-d	13.60b-d	12.97c-f	13.46b
	Seamino	1.5	14.67bc	14.03b-d	13.78b-d	14.16ab
	Seaforce x seamino	1.5	14.24bc	17.70a	13.78b-d	15.24a
						Mean effect of seaweeds
Seaweeds x temperature	0	0	12.68b	11.20c	9.82d	11.23c
	seaforce	1.5	14.09b	13.40b	12.98b	13.49b
	seamino	1.5	13.95b	13.16b	13.91b	13.67b
	Seaforce x seamino	1.5	15.52a	16.25a	13.64b	15.13a
						Mean effect of cultivars
Cultivars x temperature		Reem	14.00ab	12.71ab	12.42b	13.04b
		Karol	14.12ab	14.29a	12.78ab	13.72a
Mean effect of temperature			14.06a	13.50b	12.59ab	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level

4. Discussion

Seaweed extracts enhanced flowering and yield characters of cucumber as shown in Tables (3, 4, 5, 6, 7, 8 and 9). The increase in cucumber yield might be attributed to the increase of the distillate flowers number, which in turn enhance the number of fruits that reflected on yield/plant and total yield (Al-Saaberi, 2005). The beneficial effect of seaweed extracts on crop yield could be due to the stimulatory influence of seaweed concentrates on triggering early flowering and fruit set (Arthur et al., 2003). For instance, seedlings treated with seaweed extracts set more flowers earlier than those of control plants (Crouch and Van-Staden 1992). In many crops, yield is related to the number of flowers at maturity. As the trigger and development of flowering and the number of flowers produced are correlated with the developmental stage of plants, seaweed extracts probably promote flowering through initiation of plant growth. Yield enhancement in plants treated with seaweed extracts is thought to be associated with the hormonal substances existing in the extracts, particularly, cytokinins, this was evident in fruits treated with seaweed extracts cytokinin which had higher cytokinin levels as compared with untreated fruits (Featonby-Smith and Van Staden 1983, 1984). Cytokinin may also promote floral initiation. Transgenic *Arabidopsis* plants that are deficient in cytokinins, flower later than normal while those that have high levels of cytokinins flower earlier than normal (Bernier and Perilleux, 2005). High levels of cytokinin could refer to nutrient mobilization. Seaweed extracts are involved either in increasing the movement of cytokinins from the roots to the developing fruit, or by ameliorating the level or biosynthesis of endogenous fruit cytokinins (Hahn et al., 1974). This increase in cytokinin availability will eventually result in a greater supply of cytokinins to the maturing fruit. In addition to growth hormones, the increase in yield characters could be due to the fact that seaweed extracts contain macro, micronutrients and organic matters like, amino acids that improve nutritional status, vegetative growth and yield quality (Abd El-Migeed et al., 2004; Abd El-Moniem and Abd-Allah 2008).

Table 10

Effect of seaweed extracts, low temperature, and their interactions on yield ton.hectar^{-1} of cucumber Karol and Reem cultivars

Cultivars	Seaweed Extracts	Concentration ml/L	Exposure to low temperature 0 days	5 days	10 days	Seaweeds x cultivars
Reem	0	0	102.40gf	92.92gh	80.40h	91.90d
	Seaforce	1.5	126.24bc	116.15b-f	114.42b-f	118.94b
	Seamino	1.5	116.36b-f	108.09d-f	123.55b-d	116.00bc
	Seaforce x seamino	1.5	147.83a	130.23b	118.82b-e	132.30a
Karol	0	0	120.76b-d	104.28e-g	92.51gh	105.85c
	Seaforce	1.5	121.76b-d	119.67b-e	114.13c-f	118.52b
	Seamino	1.5	129.15bc	123.52b-d	121.26b-d	124.64ab
	Seaforce x seamino	1.5	125.36bc	155.78a	121.26b-d	134.13a
						Mean effect of seaweeds
Seaweeds x temperature	0	0	111.58b	98.60b	86.45d	98.88c
	seaforce	1.5	124.00b	117.91b	114.28b	118.73b
	seamino	1.5	122.75b	115.80b	122.40b	120.32b
	Seaforce x seamino	1.5	136.60a	143.01a	120.04b	133.21a
						Mean effect of cultivars
Cultivars x temperature		Reem	123.21ab	111.85ab	109.30b	114.78b
		Karol	124.26ab	125.81a	112.29ab	120.78a
Mean effect of temperature			123.73a	118.83b	110.78c	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan's multiple range test at 5% level

Crouch and Van-Staden (2005) found that spraying plants with concentrated seaweed extracts gave increased fruit number by 10% and fruit weight by 15%. Number of fruits per plant, fruit yield per plant and fruit yield per plot was significantly increased as a result of the application of 750 ppm of chlormequat and 1680 ppm of seaweed extract (Saravanan et al., 2003). Foliar spray of seaweed liquid extracts enhanced the yield parameters, such as, fruit length and fruit weight in certain vegetable crops (Sethi and Adhikary 2008). Better increment in fruit length, fruit diameter, and fruit number was shown by application of 2.5% of the seaweed extract *Kappaphycus alvarezii* (Zodape et al., 2009). The increase in fruits' weight in cucumber plants sprayed with seaweed extracts may refer to its role in enhancing the leaves' numbers, leaf area and dry weight and consequently the physiological activities as photosynthesis and plant nutrition provision and these could be the reasons of increasing fruit weight (Al-Saaberi, 2005). Low temperature exposure did not significantly increase flowering and yield characters of cucumber as compared with non-exposure treatments or control. Our results were not consistent with (Ausin et al., 2005), who stated the requirement of many species to low temperature exposure to warrant spring flowering. Shimizu et al. (2002) demonstrated that plants grown at low temperatures required longer time to flower as compared with those grown at optimal or increased temperatures. Flower abortion induced by low temperature could be due to the endogenous abscisic acid level. It had been found that the level of abscisic acid (ABA) in aborted flowers was higher than in retained flowers by 23% (Nayyar et al., 2005). Korkmaz and Dufault (2004) found that exposing plants to low temperature caused a profound retardation in plant flowering and decreased yield. Hongyan et al. (2011) showed that exposure of plants to low temperature decreased marketable yield and single plant yield in the first cluster fruit. Significant differences were observed between the two cultivars in relation with quantitative yield characters (Tables: 6, 7, 8 and 9). Yield is well known as a complicated phenomenon controlled by many genes and expression of such genes is continuous in nature (Hanchinamani, 2006). Passam et al. 1995 found that seaweed extracts increased early yield of one variety of greenhouse cucumber. Al-dosky (2010) noticed slight differences between yield characters of two pumpkin cultivars in response to application of the seaweed extract (Seaforce 1). Effect of seaweed extracts, four hybrids and interaction between them was significant on flowering, fruit setting and overall yield of tomato as shown by (Nour et al., 2010).

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