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EFFECT OF FOLIAR APPLICATION OF HUMIC ACID AND SEAWEEDS EXTRACT ON GROWTH AND PRODUCTIVITY OF CUCUMBER (*Cucumis sativus* L.) UNDER PLASTIC CONDITIONS

MASTER THESIS

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DEDICATION

Endless thanks to **"Allah"** who enabled me to complete this work. I am grateful to the Deanery of the Bingol University and the Department of Soil Science and Plant Nutrition for giving me the chance to complete this study.

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%	: Percentage
^oC	: Degree Celsius
m^2	: Meter square
ml	: Milliliter
cm	: Centimeter
L	: Liter
kg	: Kilogram
g	: Gram
N	: Nitrogen
P	: Phosphorus
K	: Potassium
Cl	: Chlorine
Na	: Sodium
Ca	: Calcium
Zn	: Zinc
Fe	: Iron
Mn	: Manganese
ppm	: Part per million
SWE	: Seaweed extract
HA	: Humic acid

YAPRAKTAN HÜMİK ASİT VE DENİZ YOSUNU EKSTRAKTI UYGULAMASININ PLASTİK SERA KOŞULLARINDA HIYARIN (*Cucumis sativus* L.) BÜYÜMESİ VE VERİMİ ÜZERİNE ETKİSİ

ÖZET

Duhok Politeknik Üniversitesi, Zakho Teknik Entitüsü'nün (Kuzey Irak) bitki yetiştirme alanındaki plastik sera koşulları altında (500 m^2) 2018 bahar mevsiminde, hümik asidin (HA, üç konsantrasyonu: 0, 1 ve 2 ml/L) ve deniz yosunu özütünün (SWE, üç konsantrasyonu: 0, 2 ve 4 ml/L), iki salatalık (Cucumis sativus L.) çeşidinde (Bellona F1 ve Solo F1) üzerine etkisi incelenmiştir. Bu iki biyo-uyarıcı, on gün aralıklarla üç kez yapraklara püskürtülmüştür. Salatalık tohumları 15 Şubat 2018'de plastik plastik kaplara ekilmiş ve bu fideler, 20 Mart 2018 tarihinde, damla sulama sisteminin olduğu seraya bitkiler arasında 30 cm'lik bir mesafe olacak şekilde ekilmiştir. Deneme üç tekerrürlü faktöriyel deneme deseninde (RCBD) düzenlenmiştir. Duncan'ın %0,05 düzeyindeki çoklu testleri, ortalama karşılaştırması için kullanılmıştır.

Sonuçlar şu şekilde özetlenebilir; HA ve SWE'nin yapraktan uygulanması bitki büyüme bileşenlerini (bitki boyu, toplam klorofil, yaprak sayısı ve bitki kuru maddesi) ve yapraklardaki (N, P ve K) mineral içeriğini önemli ölçüde arttırmıştır. Vejetatif büyüme karakterlerinin çoğu için iki salatalık çeşidi arasında anlamlı bir fark bulunmamıştır. Bununla birlikte, Solo F1 çeşidi, Bellona F1'den bitki boyu ve kuru madde bakımından önemli ölçüde farklılık göstermiştir. Üç faktör (HA, SWE ve çeşitler) arasındaki interaksiyon, vejetatif büyüme karakterlerinin çoğunda önemli olduğu belirlenmiştir. Üçlü interaksiyonda ise, vejetatif büyüme özelliklerinde (bitki uzunluğu, yaprak sayısı, toplam klorofil, bitki kuru maddesi ve yaprak alanı) önemli bir artış olduğu gözlenmiştir.

Hümik asidin uygulanması, nicel ve nitel verim karakterlerini (erken verim, toplam verim, meyve sayısı, meyve ağırlığı, meyve uzunluğu, meyve çapı ve toplam çözünür katı maddeler, TSS) belirgin şekilde arttırmıştır. SWE'nin etkisi ise (meyve sayısı hariç), tüm niceliksel ve niteliksel verim karakterleri için önemli bulunmuştur.

Anahtar Kelimeler: Hümik asit (HA), Deniz yosunu ekstraktı (SWE), *Cucumis sativus* L.

EFFECT OF FOLIAR APPLICATION OF HUMIC ACID AND SEAWEEDS EXTRACT ON GROWTH AND PRODUCTIVITY OF CUCUMBER (*Cucumis sativus* L.) UNDER PLASTIC CONDITıONS

ABSTRACT

A field experiment was conducted in a plastic house (500 m^2) at vegetable research field of the Department of Protected Cultivation, Zakho Technical Institute, Dohuk Polytechnic University, North Iraq during spring season of 2018 to investigate the effect of humic acid (HA, with three concentrations: 0, 1 and 2 ml/L) and seaweed extract (SWE, with three concentrations: 0, 2 and 4 ml/L) on two cucumber (*Cucumis sativus* L.) cultivars, i.e., Bellona F1 and Solo F1. The two bio stimulants were sprayed three times with ten days' interval. Cucumber seeds were sown in plastic pots on February 15th 2018 kept in plastic house. The cucumber seedlings were planted on March 20, 2018 at a distance of 30 cm between plants along the perforated hose line of drip irrigation system. The experiment was arranged in a factorial Randomized Complete Block Design (RCBD) with three replicates. The Duncan's multiple range tests at 0.05% level was used for means comparison.

The summary of main results was as follows; Foliar application of HA and SWE significantly increased vegetative growth components (plant length, total chlorophyll, number of leaves and plant dry matter) and mineral contents in leaves (N, P, and K). No significant differences were found between the two cucumber cultivars for most of the vegetative growth characters. However, Solo F1 cultivar significantly differed from Bellona F1 regarding plant height and dry matter. The interaction between three factors (HA, SWE and cultivars) resulted in significant improvement of most vegetative growth characters. The three-way interaction caused a significant increment in the vegetative growth traits (plant length, leaf number, total chlorophyll, plant dry matter and leaf area). Application of HA significantly increased quantitative and qualitative characters of yield (early yield, total yield, number of fruits, fruit weight, fruit length, fruit diameter and total soluble solids, TSS). The effect of SWE was significant for all quantitative and qualitative yield characters, except number of fruits which was not influenced by SWE application.

Keywords: Humic acid (HA), Seaweed axtract (SWE), Cucumber (*Cucumis sativus* L.).

1. INTRODUCTION

Cucumber is one of the most important vegetable crops and a creeping vine that has cylindrical fruits. The scientific name of cucumber is *Cucumis sativus* and is one of the valuable members of the gourd family Cucurbitaceae which consists of Melon, squash, Watermelon and Pumpkins (Bello *et al*., 2014). The plant originated from Asia continent (Abulude *et al*., 2010). It is warm season annual crop that can thrive and grow in both temperate and tropical areas; therefore, it is a native of many regions of the world (Mortimore, 2015). Many varieties of cucumber are available but according to the edibility index, it is divided into three groups, i.e., the slicing, pickling and burpless.

Cucumber is rich in nutrients and vitamins necessary for the body development (Sunday and Hernetta, 2012). It is also beneficial for human health and effective in rehydration of the body, reducing high the blood pressure, preventing body overweight, cholesterol reduction, cancer prohibition, bone protection, diabetes treatment and antioxidant activity (Kumar *et al*., 2010; Bello *et al*., 2014; Naganatha and Hartline, 2015). Cultivation of cucumber requires soil types which possess a high water holding capacity and good drainage. It also requires soil rich in organic matter and manure. The optimum soil pH for cucumber production ranges from 5.5 to 7.0 (Ekwu *et al.,* 2007).

The use of naturally derived bio stimulants or bio fertilizers as a substitute for harmful chemical fertilizers is becoming a promising synergistic factor and is earning importance and attention worldwide (Colla *et al.,* 2015; Rouphael *et al.,* 2015). Plant bio stimulants (PBs) are convenient and consistence for application to plants with the goal to improve nutritional status, plant growth, crop quality attributes, and abiotic stress tolerance irrespective of nutritional facts. These natural and ecofriendly substances are classified into seven categories; seaweed extracts, humic and fulvic acids, protein hydrolysates, chitosan, inorganic compounds, beneficial fungi, and bacteria (du Jardin 2015).

Seaweed extracts are natural fertilizers extracted from marine algae that are nonflowering plants which do not have true shoots, stem and leaf system. Algae are classified according to their pigments into three groups; green, brown and red. These extracts are generally available in two formulas either as soluble powder or as liquid fertilizer extracts drenched to the soil near roots of the plant or sprayed to the plant foliage (Battacharyya *et al.*, 2015). Seaweeds, especially brown algae (Phaeophyceae) are well-known to contain a considerable amounts of sterols, polysaccharides, N-containing compounds (e.g., betaines), macro and micronutrients as well as several growth promoting hormones such as auxins, cytokinins, gibberellins, and brassinosteroids (Khan *et al.*, 2009; Craigie 2011). Seaweed extracts not only ameliorate plant growth, yield and quality, but also stimulate plant resistance to cruel external conditions by increasing metabolic paths leading to build up antioxidant molecules in plant cells (Thirumaran *et al.*, 2009).

Humic substances namely, humic acid, fulvic acid are the main constituents (65-70%) of soil organic matter. They can enhance plant growth efficiently through motivating cell membrane permeability, photosynthesis, respiration, oxygen and phosphorus uptake and providing root cell growth (Cacco and DellAgnolla, 1984**,** Russo and Berlyn, 1990; Fahramand *et al.*, 2014). Humic acid possesses hormone-like action which, in addition to increasing the plant growth and the nutrient uptake, exhibit an anti-stress activity against abiotic stress conditions like extreme temperature, pH, and salinity by suppressing the adverse influence of any external stress (El-Hefny, 2010). Humic acid, as a commercial production, consists of 42- 46% O, 44-58% C, 0.5-4% N and 6-8% H as well as other important elements.

1.2. The Aim of the Study and Objectives

The use of chemical fertilizers is intensive in Iraq generally, and in northern region particularly. Since the bio stimulants are available and are safe and effective for vegetable production, this field study was conducted to: 1. Test and evaluate the effect of seaweed extracts, humic acid and their interaction on cucumber growth and productivity, 2. To provide a safe and healthy produce free from dangerous substances that do not harm the human health and protect environment from adverse effects of chemical fertilizers, 3. To pay attention and focus on organic farming as a step towards sustainable crop production.

2. LITERATURE REVIEW

2.1. Humic Acid

General Overview

The continuous application of chemical fertilizers for increasing vegetables' production had posed detrimental effects on human health and the environment. Therefore, seeking for alternatives to replace the hazardous chemicals has been extensively increased to put a limit for excessive use of chemical fertilizers by farmers all over the world. The best substitutes for these chemicals are natural and organic fertilizers that are safe for health and produce high quality and healthy yield with enhanced nutrient elements in the soil along with improving physical, chemical and biological properties of soil (Al-Sehaf, 1989).

Foliar application of humic acid has shown an improvement in plant growth, and enhanced yield and quality in several plant species (Brownell *et al.*, 1987; Yildirim, 2007; Karakurt *et al.*, 2009) through improved nutrient uptake and acting as a source of mineral nutrients (Chen and Aviad, 1990; Atiyeh *et al.*, 2002). The previous investigations revealed that humates have profound impact on nutrient supply to the plants. Hence humates was a favorable trial material used as an approach to enhance the nutrient content and vitality in plants (Boehme *et al.*, 2005). These substances are natural substances made by the decomposition of organic matter and used as soil fertilizers because of their ability to enhance soil fertility and soil microbial activity (Unlu *et al.*, 2011).

2.1.1. Effect of Humic Acid on Vegetative Growth

Humic substances exhibited a positive role in the stimulation of shoot and root growth and uptake of nutrient in vegetable crops (Tattini *et al.*, 1990; Padem *et al.*, 1997; Akinremi *et al.*, 2000; Cimrin and Yilmaz, 2005). Bayoumi and Hafez (2006) illustrated that organic fertilizers applied as foliar spray with different concentration led to a significant enhancement in the Cucumber growth characteristics which in turn had appositive impact on the yield and nutrient elements in leaves. A field trial was done by Eyheraguibel *et al.* (2008) to determine the effect of humic like substance on seed germination, growth, development and mineral nutrition of cucumber grown hydroponically. The gained data showed that the humic like substance improved plant growth as well as root, shoot and leaf biomass. El-Shabrawy *et al.* (2010) revealed that soil application of humic acid led to a significant increase in the dry weight and the total yield of cucumber.

Mora *et al*. (2010) observed in a field study that the humic acid prominently promoted vegetative growth characters, especially the shoot growth of cucumber. In another field research, Yousif (2011) found that the foliar and soil application of humic acid significantly enhanced vegetative growth (chlorophyll, dry weight) of cucumber in comparison to untreated plants. El-nemr *et al.* (2012) conducted a field trial detecting the influence of foliar application of humic acid (0, 1, 2 and 3 g/L) and bio-stimulators (0.45 cm/L Ecormon, 0.60 g/L Amcotone and 0.60 g/L Tchnotone) on growth and yield of cucumber. The results showed that the foliar spray of humic acid and biostimulators resulted in increased vegetative growth and yield with a significant effect of the higher concentration of humic acid (3 g/L) and Ecormon (0.45 cm/L).

Meena *et al*. (2014) performed an experiment inspecting the influence of humic acid and micronutrient elements on the performance of cucumber and revealed that humic acid and micronutrients significantly increased the vegetative growth traits, i.e., vine length (cm), number of branch per plant and leaf area (cm^2). Aisha *et al*. (2014) found that increasing level of humic acid resulted in a remarkable increase in the growth parameters, root yield of turnip. Shafeek *et al*. (2014) cleared that, hot pepper plants treated with (2 g/L) of humic acid possessed improved growth characters such as plant height, stem number and leaf chlorophyll content as compared to control. Shafeek *et al*. (2016) conducted a field trial to check out the influence of foliar or ground drench application of humic acid on growth of cucumber grown in plastic house conditions**.** The results showed that both foliar and ground application of humic acid significantly improved vegetative growth of the plant as compared to control. Yaser et al. (2016) carried out a trial investigating the effect of humic acid on the growth and yield of cucumber grown in green house. The data showed that the application of humic acid had a superior influence on vegetative growth (the dry weight of the plant and the percentage of chlorophyll, nitrogen, and potassium, and holds rate per plant).

2.1.2. Effect of Humic Acid on Yield

The use of humic acid as a biofertilizer for obtaining optimum growth and yield of squash (*Cucurbita maxima* L.) has been investigated and the trial data unveiled that beside increasing the squash growth, humic acid played a dominant role in improving fruit yield and quality of crop (Hafez, 2004). Boehme *et al*. (2004) reported that application of full soluble Fe-humate from two different coal sources significantly improved the yield of cucumbers (*Cucumis sativus* L.) and remediated iron deficiency. Salman *et al.* (2005) reported in another study that humic acid applied through drip irrigation to water melon (*Citrullus lanatus*) resulted high quality of marketable yield. Asmaa *et al.* (2010) studied the effect of humic acid on growth and yield of potato (*Solanum tuberosum*). They showed that tuber yield and quality were notably enhanced when humic acid level was increased from 0 to 4.8kg humic acid/ha. El-Shabrawy *et al.,* (2010) illustrated that adding humic acid with some biofertilizers (humic acid and azotobacter) greatly increased yield of cucumber.

The okra plant (*Hibiscus esculentus* L.) was also remarkably influenced by application of humic acid. The biofertilizer was significant in enhancing flower to fruit conversion ratio, higher shoot fresh weight, fruit yield with recommended fertilizers (Kirn *et al*., 2010). The foliar addition of humic acid (20ml/L) to cucumber plants grown in plastic house resulted in a remarkable increase in the total yield of crop (Unlu *et al.,* 2011). Yousif (2011) pointed out that the foliar and drench application of humic acid significantly enhanced the total yield of cucumber. Mostafa, M. R. (2011) implemented a field trial to investigate the impact of humic acid along with farmyard manure on the growth, leaf mineral composition, fruit yield and quality of tomato on newly reclaimed soil. It was reported that humic acid and manure significantly increased fruit yield and quality of tomato. Magdi *et al.* (2011) found in another field research that combining humic substances and mineral fertilizers led to considerable increase in growth and yield of cowpea (*Vigna unguiculata*). It was demonstrated that spraying cucumber plants with (1.5g/L) of humic acid weekly produced tallest plants along with the highest number of internodes per plant (Shehata *et al.* 2012). In another study, Sure *et al*. (2012) found that application of two biofertilizers (humic acid and nitroxin) had a significant influence on the productivity and quality of cucumber. The biofertilizer mixture improved fruit diameter, length and fruit yield ha^{-1}.

Fahmy, (2012). carried out a study to investigate the effect of humic acid and some other treatments on the growth and yield attributes of cucumber and water melon crops. The highest fruit weight and fruit yield per plant was measured for plants receiving humic acid. Kazemi (2013) performed a field study to evaluate the impact of humic acid and potassium nitrate on the growth of cucumber. The gathered data showed that the humic acid and potassium nitrate were notably prominent in increasing fruit quality. Meena *et al*. (2014) studied the impact of humic acid on the performance of cucumber and cleared that humic acid was increased yield traits like number of fruits per vine, fruit weight (g), fruit length (cm), fruit diameter (cm), volume of fruit (cc), yield per plant (kg) and yield per square meter (kg). Sahin *et al.* (2014) inspected the effect of humic acid and phosphorus on yield of cucumber and stated that humic acid and phosphorus increased dry matter yield.

Humic acid significantly promoted total yield and yield quality of hot pepper (Shafeek *et al.*, 2014). The effect of humic acid on growth and yield of squash was investigated and a valuable improvement in fruit yield $plant^{-1}$ was recorded (Jasim *et al.*, 2015). Yasir *et al.* (2016) showed that humic acid along with the organic fertilizer (Vegeamino) improved the total yield of the cucumber crop. Abdellatif *et al.* (2017) conducted a field study to evaluate the impact of humic acid on growth and productivity of tomato. They earned great results from humic acid application in relation to flowering parameters (number of flower clusters and flowers per plant) as well as yield characters (fruit number per plant and fruit weight, which resulted in higher early and total yield). Alkharpotly *et al.* (2017) carried out a field study to test the influence of humic acid and seaweed extracts on growth, yield and fruit quality of strawberry (*Fragaria* × *ananassa Dush*.). The results of experiment showed that the mixture of both humic acid and seaweed extracts was superior in improving the yield characters of the plant.

2.1.3. Effect of Humic acid on Mineral Content

El-Ghamry *et al.* (2009) showed that the addition of humic acid through drip irrigation with concentrations (1000, 2000 or 3000 ppm) resulted in a profound increase of N, P and K content in seed and straw of bean plants. Selim *et al.* (2009) showed that humic substances applied by drip irrigation method prohibit nutrients leaching, which resulted in adequate enhancement of macro and micronutrients levels in potato tubers and at the same way increasing concentration of such nutrients in soil after tubers are harvested. The application of humic substances was a beneficial approach to amend plant growth and chemical composition, which in turn perfectly promoted a higher crop yields and quality (Mahmoud and Hafez, 2010; Hanafy Ahmed *et al.*, 2010; Osman and Rady, 2012). Tehranifar and Ameri (2012) have found in a field trial that humic acid applied to strawberry plants caused a significant improvement in nutrient uptake (N, P and K). In a field study which was conducted to assess the effect of humic acid prepared as water solution with three concentrations (0.5, 1.0 and 1.5 g L^{-1}) added to soil on the growth of squash. The concentrations of nitrogen (N), phosphorus (P) and potassium (K) in leaves were enhanced, whereas the sodium (Na) and chlorine (Cl) concentration were decreased (Jasim *et.al.*, 2015).

Ekinci *et al.* (2015) conducted a field trial to evaluate the effect of calcium and boron humate on nutrient uptake in cucumber and indicated a significant increase in the macro and micronutrients in leaves and fruits. El- Asri *et al.* (2015) carried out a research to investigate the influence of soil applied humic acid (0, 40, 80, 120, 160, 200 L/ha^{-1}) on fruit quality and nutrient concentration in tomato. It was reported that N, P, K, Ca, Zn and Mn concentration of leaves was enhanced by humic acid, especially 80 L ha^{-1} humic acid level. Sonmez and Gulser (2016) studied the impact of humic acid and calcium nitrate on the growth and nutrient uptake of pepper. The plants receiving humic acid had the highest K, Ca, Fe, Mn, Zn and P contents as compared with control treatment of the study. The beneficial influence of foliar applied humic acid on growth; yield and nutrient content of tomato crop was studied and it was observed that vegetative growth parameters and nutrients content (N, P, K and Ca) were remarkably increased by humic acid (Khaled and Fawy, 2011).

Yasir *et al.* (2016) studied the effect of humic acid and organic fertilizers on growth and yield of cucumber and reported a significant enhancement in N and K contents. A greenhouse experiment to evaluate the effect of humic acid and salicylic acid sprayed to the foliage of strawberry indicated the humic acid significantly increased leaf K, P, Ca and Mg irrespective of the humic acid concentration (Aghaeifard *et al.*, 2016).

Prakash *et al*. (2018) studied the influence of humic acid and seaweed extracts on the growth and nutritional quality of okra crop and found that application of a mixture of humic acid and seaweed extracts significantly enhanced yield and produced fruits with high nutritional value when compared to untreated plants.

2.2. Seaweed Extracts

General Overview

Seaweed extracts are modern type of natural organic fertilizers which contain effective nutritious substances which faster germination of seeds and enhance growth, yield, and tolerance ability of various crops. The extracts made from seaweeds are readily biodegraded in contrast to chemical fertilizers. These extracts are also non-toxic, ecofriendly, and have no hazards on the human, animals and bird health (Dhargalkar and Pereira, 2005). Seaweed extracts are well-known for their enrichment of macro and micro nutrients, numerous necessary hormones for plant growth like auxins, gibberellins and cytokinin which promote cell division and cell enlargement contributing in the balance of physiological and biological processes, improving the photosynthesis process and increasing growth (Jensen, 2004; Erulan *et al.*, 2009).

Seaweed extracts stimulate plant resistant to diverse environmental conditions through increase of antioxidant enzymes that protect plants against stresses (Schmidt, 2005). A significant enhancement in stem length, plant dry weight, chlorophyll and nitrogen, phosphorous and potassium content in leaves of cucumber plants has been observed with foliar application of seaweed extract (Abdulraheem, 2009). The application of seaweed extract to various economic crops is required for optimum growth and high quality yield since these extracts have a high content of necessary substances such as organic matter, micro elements (Fe, Cu, Zn, Co, Mo, Mn and Ni), amino acids and vitamins in addition to high levels of plant hormones (Khan *et al*., 2009). The exogenous application of seaweed extracts has resulted in improved plant growth, enhanced quantitative and qualitative yield characters (Abou El-Yazied *et al*., 2012).

2.2.1. Effect of Seaweed Extracts on Vegetative Growth

Muhammad (2009) reported that cucumber plants receiving seaweed extract (Seaforce1) with concentration 2ml/L. for once, twice and three times in combination with (N) fertilizer led to a remarkable increase in stem length, dry weight and chlorophyll content. Nour *et al*. (2010) reported that foliar spray of seaweed extracts on tomato hybrids has significant influence on plant vegetative characters and resulted in the highest values of plant height, number of shoots/plant as well as total dry weight. Seaweed extracts greatly improved vegetative growth of potato crop (Al-bayati, 2010). Zodape *et al*. (2011) concluded that spraying seaweed extracts to the foliage of tomato plants resulted in a significant increase in estimated vegetative characters by 60.89% when compared to control plants and stimulated total chlorophyll content in leaves. Ahmed and Shalaby (2012) conducted a study to evaluate the impact of seaweed extracts (red and green alga), compost and the commercial seaweed extract Algreen on cucumber hybrid Prince. The test data showed that foliar applied seaweed extracts made a significant increase in vegetative growth characters and yield of cucumber plant.

Abou El-Yazied *et al.* (2012) has reported a significant increase in number of leaves per plant, average leaf area, leaf and stem fresh weight per plant, leaf and stem dry weight per plant by foliar sprayed seaweed extracts (750 ppm) to snap bean plants. Dalia *et al.* (2014) investigated the influence of seaweed extract and nitrogen fertilizers rate on growth and yield of peas. The experiment consisted of twelve treatments represented by the combinations between three levels of mineral N fertilizer (50, 75 and 100% of recommended mineral N rate) and four concentrations of algae extract (0, 5, 10 and 15% W/V). The test results demonstrated that pea plants treated with 10 or 15% algae extract made a significant enhancement in the measured vegetative growth parameters and improved leaf chlorophyll content in comparison with the other algae extract treatments. Marhoon and Abbas (2015) tested the effect of seaweed extracts with concentrations (0, 3 or 6 ml. L^{-1}) and amino acids on some vegetative and anatomical characters of two sweet pepper cultivars. They reported a significant enhance in plant height, number branches and the percentage of dry matter of shoots in both cultivars when treated with seaweed extract at 6 ml L^{-1} and amino acids at 800 mg.L^{-1}.

The effect of seaweed extracts and amino acids on growth and productivity and some bio-constituents of common bean have been studied in two experiments. It was concluded that different doses caused a significant increase in the measured vegetative growth components such as plant height, stem diameter, number of branches and leaves/ plant, total leaf area /plant, dry weight of shoots and specific growth rate as well as profound enhance of photosynthetic pigments and total chlorophyll SPDS with increasing seaweed and amino acid sprayed levels at the age of 65 days after sowing (Zwilla, 2014). Another experiment conducted to study the effect of foliar spraying with licorice root and seaweed extracts on growth and seed production of onion concluded that all vegetative traits (plant height, length of the tallest leaf and number of leaves leaf/plant) were significantly increased by the application of a combination of both natural fertilizers as compared to control plants (Babilie *et al*., 2015).

El Sagan (2015) studied the influence of some natural extracts, namely sea algae (0.5, 1 and 1.5 g/l), compost (50, 100 and 150 g/l), licorice (2.5, 5 and 7.5 g/l) and yeast (2.5, 5 and 7.5g/l) on growth of cucumber. The results revealed foliar sprays of yeast (7 .5g/l), algae extract (1.5g/l) and compost tea (150 g/l) significantly improved vegetative growth characters such as plant length, plant weight, and average of leaf area. Selvakumari1 and Venkatesan (2017) studied the effect of seaweed gel on growth and yield of tomato Hybrid COTH and indicated a significant promotion in plant height, number of leaves, number of branches and leaf area index in plants received seaweeds gel. Rouphael *et al*. (2017) investigated the influence of seaweed extract on yield, chemical composition and leaf anatomy of zucchini squash. They found that seaweed extract increased shoot biomass and enhanced chlorophyll content in the leaf. Oyoo *et al.* (2017) inspected the impact of bio-stimulators (humic acid and seaweed extracts) on growth and yield of cowpeas and concluded that interaction of both bio-stimulators enhanced vegetative growth characters such as plant height, leaf area, chlorophyll content and nodule development as compared to control plants.

2.2.2. Effect of Seaweed Extracts on Yield

It has been reported that foliar application of seaweed extracts (Seaforce 1) significantly affected number of male and female flowers, sex expression ratio and this positively reflected on the total yield of cucumber (Al-jebbouri, (2009). Al-Dosky (2010) clarified that foliar spray of seaweed extracts (Seaforce 1) decreased the number of days for initiation of the first flower and led to an increase in number of female flowers subsequently improved total yield of squash plants. Similarly, seaweed extracts increased the yield component of water melon (Abdel-Mawgoud *et al*., 2010). Sarhan *et al*. (2011) investigated the impact of bread yeast and seaweed extracts on cucumber growth, yield and fruit quality. A prominent increase in all yield characters was been observed due to application of yeast and seaweed extracts and plants receiving (6 g L^{-1}) bread yeast mixture of (0.33 ml L^{-1} Alga 600 +2.5 ml L^{-1} Seaforce 2) possessed the highest yield components and fruit quality

A field trial was conducted to evaluate the impact of the seaweed extract (Algean) and growth regulator (Atonik) on growth and yield of cucumber grown under plastic house. The experiment result revealed that both growth regulators positively influenced flowering and yield characters of cucumber (Obeid *et al.*, 2011). Kumari *et al.* (2011) studied the effect of different concentrations (0.1, 0.4, 0.8, 2, 6, 8 and 10%) of seaweed extract on growth and yield of tomato and significant improvement was noted in yield parameters (flower number, fruit number and fresh weight) and biochemical constituents (photosynthetic pigments, proteins, total soluble sugars, reducing sugars, and vitamin C). An experiment was done by Sarhan (2011) to evaluate the impact of humic acid and the seaweed extracts Alga 600 and seaforce 2 on potato growth and yield. The experiment data illustrated that both seaweeds and amino acid and their interaction promoted yield. Fawzy *et al.* (2012) tested the effect of foliar spraying of seaweed extracts and some other bio stimulants on growth and yield components of garlic and reported a significant improvement in yield and quality. Haidar *et al*., (2012) studied the influence of seaweed extracts on growth, yield and quality of potato**.** The highest tuber yield was recorded with seaweed extract at 90 days' interval after planting. The extract also caused a significant increase in nitrogen, total soluble solids and protein contents of the potato tubers**.**

Suhail (2013) evaluated the effect of mycorrhizal fungi inoculation and seaweed extract sprays on growth yield characters of cucumber grown in greenhouse. The seaweed extracts in combination with mycorrhizal fungi significantly influenced yield traits in terms of number of fruits, yield per plant and total yield which were maximum in plants treated with 2.5 ml l^{-1} seaweed extract along with fungus mycorrhiza when compared to other treatments. Doss *et. al.* (2015) found that sweet potato plants sprayed with seaweed extracts exhibited a positive response in concern to yield and its components. El Sagan (2015) noticed an increase in fruit weight, number of fruit/plant, yield and chemical content of cucumber plants when their foliage were sprayed with yeast extract at the level of 7.5g/L, algae extract (1.5 g/L) and compost tea extract (150 g/L), respectively. The influence of seaweed concentrate (Kelpak®) and effective microorganisms (EM) on growth and yield of cabbage were studied and the results demonstrated that (EM + Kelpak®) enhanced weight of fresh leaves, fresh head, stem diameter and head polar diameter (Satekge *et al*., 2016).

Kocira *et al*. (2017) conducted explored the influence of seaweed extracts on yield and protein content of two common bean cultivars. The maximum number and weight of grains were measured in plants treated with 0.2% of seaweed extracts as well as the highest protein content of grains in both bean cultivars. Rouphael *et al*. (2017) indicated that foliar application of seaweed extracts enhanced yield and shoot biomass of zucchini squash crop by 12.0 and 17.4%, respectively, as well as fruit dry matter and total soluble solid contents as compared to control plants. Selvakumari1 and Venkatesan (2017) observed a significant increase in yield components of tomato plants. Alam *et al*. (2013) performed a field research to explore the effect of the seaweed extract Ascophyllum on growth and yield of strawberry and results showed an enhanced beery productivity in plants treated with 1 and 2 g of soluble Ascophyllum extract powder in comparison with other treatments. Alkharpotly *et al*. (2017) inspected the influence of soil application of humic acid and foliar spray of seaweed extracts on growth yield and fruit quality of strawberry. They indicated that soil humic acid at a rate of 400 mg/L combined with seaweed extract spray (1500 mg/L) produced the highest values of yield characters which were obvious in early yield, yield/plant and total yield.

2.2.3. Effect of Seaweed Extracts on Mineral Content

Foliar spray of seaweed extracts (Seaforce 1) to cucumber plants was the reason for significant enhancement in leaf content of (N, P and K) (Muhammad, 2009). Zodape *et al*. (2010) focused on the effect of seaweed extracts on yield and nutritional value of mung bean and reported a significant enhance in the yield and nutritional values of seeds attributed to the seaweed fertilizer. Mawgoud *et al.* (2010) revealed that foliar application of the seaweed extract (*Ascophyllum nodosum*) two times was superior in term of increasing mineral content of N, P and K in three hybrids of watermelon. Al-Hermizy *et al.* (2011) discovered the positive impact of the foliar application of seaweed extract (Alga 300) on mineral content of strawberry plants and showed that the extract significantly improved the nutrient concentrations (N, P and K).

Shehata *et al*. (2011) conducted a field study to investigate the influence of amino acids and seaweed extract with different concentrations on chemical constitutes, yield and quality of celeriac plant**.** The results illustrated that spraying seaweed extracts with the highest rate possessed the maximum values of P and K content of leaves, whereas the maximum value of N content in leaves belonged to the highest level of applied amino acids. The seaweed extract (Alga 300) was given to strawberry as foliar sprays during a field trial and a significant influence of the seaweed fertilizer on the plant was recorded in terms of increased growth, yield and N, P, K concentrations in strawberry plants (Al-Hermizy *et al.*, 2011). Zodape *et al.* (2011) inspected the impact of the seaweed on growth and yield of tomato and demonstrated that foliar spraying of seaweed notably promoted yield and macro and micro elements content.

El-Miniawy *et al*. (2014) investigated the effect of foliar application of seaweed extracts (1.0 or 2.0 ml/l) on growth, yield and mineral content of strawberry and concluded that foliar application significantly improved leaf P and K contents, but did not affect the N content. In tomato crop, the exogenous application of seaweed extracts caused a significant increase of Mn, Zn and Fe uptakes, and chlorophyll content (Hernández-Herrera *et al*., 2014). Plants treated with *Ascophyllum nodosum* extract (ANE) owned higher nutrient uptake and were capable of producing fruit with higher nutrient content. Zewail *et al*. (2014) studied the effect of seaweed extracts and amino acids on growth, productivity and some biochemical constituents of common bean and observed an improvement in biochemical constituents (N, P, K, Mg, Ca, Fe and Zn). Dalia *et al*. (2014) measured the maximum values of N, P and protein in the grains of pea plants sprayed with algae extracts (10 or 15%). The positive impact of seaweeds on mineral content had been proved in a field research which showed that application of *Ascophyllum nodosum* extract on tomatoes resulted in maximum nutrient counts for N (81%), P (8%), K (50%), Ca (570%), Fe (250%), and Zn (33%) as compared to the control tomatoes (Ali *et.al*., 2015).

El Sagan (2015) found out that the algae extracts (1.5 mg/L) used as foliar was responsible of significant increments in cucumber plant growth and yield parameters as well as chemical content (N, P and K) content of leaves.

Demirkiran and Cengiz (2010) found that the nutrient contents of pistachio leaves were increased by applying different organic materials (gyttja, alsil, humic acid, sea moss, straw and peat).

2.3. Cultivar

General overview

In general cucumber varieties are classified into three categories; slicing, pickling and burpless. Numerous cultivars of cucumber have emerged within these varieties. There are many cucumber cultivars that are present with different shapes, skin colors and carotene content (Simon, 1992). Cucumber cultivars are common in having distinctive characteristics that make them convenient for specific environmental conditions, like tolerant to drought, disease resistance and early maturing and yield.

In order to achieve sustainable crop production, good quality crop is required with good taste, early maturity, enhanced yield, insect/pest resistant, more nutritive and can immediately supply human requirements in terms of food and raw materials (Ilodibia *et al*., 2014; Ilodibia *et al*., 2015). Therefore, extensive efforts have been done by breeders to improve the yield of several crops such as cucumber, tomato, okra etc. (Chen *et al*., 1999; Khalf-Allah and Mousa, 1972).

2.3.1. Effect of Cultivar on Vegetative Growth

Maqsood *et al.* (2004) studied the performance of six cucumber cultivars and observed significant variation among cultivars in term of vegetative growth. Ahmad *et al.* (2004) found significant variations for vegetative growth between six cucumber cultivars. Ojeifo *et al*. (2008) conducted a field experiment to investigate the growth and yield of five cucumber varieties. The trial data showed significant differences between the varieties relating to vegetative growth traits. A field trial was carried out by

Nour *et al.* (2010) to study the influence of seaweed extracts and hybrids on the growth and yield of tomato. The data showed a significant influence of seaweed extract, hybrid and interaction between them on vegetative growth parameters of the plant.

Sarhan and Ismael (2014) found significant differences between the two hybrids in term of vegetative growth parameters. Nwofia *et al.* (2015) recorded significant differences between three cucumber varieties in terms of vegetative growth characters. Adinde *et al*. (2016) carried out a field trial to evaluate the performance of four cucumber cultivars namely, Ashely, Marketer, Super-marketer and Pointsett-76. The obtained data unveiled significant differences between the four cultivars regarding vine length, number of leaves per plant, number of branches per plant and leaf area with superiority for the Pointsett-76 as compared to other three cultivars.

Maaz *at el.* (2017) conducted a study to estimate the effect of organic fertilizer on growth and yield of cucumber cultivars (Desi 36 Days, Market more, Poinsett 76 and S. Green). The results indicated significant differences between the cultivars respective to vine length, number of branches per plant, number of leaves per plant and leave area. S. Green was better than other cultivars. Al-bayati (2010) carried out a field trial to study the effect of seaweed extracts on the growth and yield of two potato cultivars (Desiree and Latona) and reported significant differences between the cultivars in term of vegetative growth traits.

2.3.2. Effect of Cultivar on Yield

Al-Dosky (2010) conducted a field study to investigate the effect of the seaweed extract (Seaforce1) on growth and yield of two pumpkin cultivars (Karol and Reem) and indicated significant differences between the two cultivars regarding to the yield components. El-Nemr *et al*. (2012) carried out a field trial detecting the influence of humic acid on growth and yield of cucumber and found that foliar application of humic acid significantly improved yield characters of Beta-Alpha (Quartz F1) cultivar in term of number of fruits per plant, fruit weight, fruit length, fruit diameter and yield (kg/plant). Sarhan and Ismael (2014) reported significant differences between two cucumber cultivars in term of number of fruits per plant, fruit weight, yields (kg/plant, kg/m).

Adinde *et al.* (2016) reported that cucumber cultivars were significantly different from each other concerning the yield characters (number of fruits, weight of a fresh fruit, fresh fruit weight and fresh fruit yield) and the best one was Pointsett-76 as compared to other three cultivars (Ashely, Marketer and Super-marketer).

Maaz *et al*. (2017) found significant differences between yield characters of four cucumber cultivars (Desi 36 Days, Market more, Poinsett 76 and S. Green) with respect to their response to application of organic fertilizers. Ilodibia *et al.* (2018) performed a field experiment to study the effect of breeding on the growth and yield of cucumber using four varieties (Darina hybrid, Local Slicing, F1 Hybrid and p-value). The result showed that the F1 Hybrid possessed the highest number of fruits and the Darina hybrid had the highest fruit weight.

2.3.3. Effect of Cultivar on Mineral Content

The differences between cultivars in relation to nutrient concentrations are mostly attributed to yield difference between the cultivars. Gomez *et al.* (2003) showed significant differences between cucumber cultivars regarding the nutritional status. Jilani *et al.* (2009) revealed significant differences between cucumber cultivars in term of nutrient concentration and they referred this variation in nutritional status to the difference in the yield components. Mawgoud *et al.* (2010) carried out a field trial to inspect the effect of foliar application of the seaweed extract on growth and yield of three watermelon hybrids. The data indicated that the three hybrids significantly differed from each other in nutrient contents represented by N, P and K percentage in leaves.

Abdelaziz (2010) conducted a two- season field study on two cucumber cultivars (Passandra and Girola) investigating the effect of substrate on growth, yield and mineral content of the crop. The results revealed that two cultivars were significantly variant from each other in term of nutrient element content. Nitrogen in fruits of cultivar Passandra and P, K, Ca in fruits of cultivar Girola showed higher significant increases in the first season. El-Nemr et al. (2012) reported in a field experiment that there was significant enhancement in the mineral content (N, P, K, Ca and Mg) in leaves of the cucumber cultivar Beta-Alpha (Quartz F1) in response to foliar application of humic acid. Sarhan and Ismael (2014) found significant differences between two cucumber cultivars (Karol and Reem) in mineral content (P, Ca and Mg) of leaves with SWE appling.

3. MATERIAL AND METHOD

3.1. Study Location

The field trial was carried out in a plastic house (500 m^2) at vegetable research field of Protected Cultivation Department, Zakho Technical Institute, Dohuk Polytechnic University, Iraq during spring season of 2018.

3.2. Soil of Study Location

The study site soil was clay. The soil samples were taken randomly from several sites of plastic house at a depth of (25-30 cm). The soil samples were air dried and then sieved using a 2.0 mm sieve for soil analysis. The physico-chemical properties of experimental soil are summarized in Table 3.1.

Table 3.1. Some physical and chemical properties of the plastic house soil

Available nutrient content		
Soil texture	Texture	Clay
Total –N	(%)	0.1
Available phosphorus	(%)	0.16
Available potassium	ppm	50
Organic matter	(%)	2.9
pH	1:1 in paste	6.7
Electrical conductivity	($ds.m^{-1}$)	25.6

3.3. Preparation of Plastic House Field

The soil of plastic house was well ploughed then softening of soil was carried out. After that organic manure of cattle was applied to the soil. The organic matter is beneficial for soil because it's a good source of nutrient elements and binds soil particles together forming aggregates, ameliorates the soil water – holding capacity of soil (particularly sandy and loamy soils), enhance water permeability into soil, promoting the production of metal-organic matter complexes (e.g. with the Fe, Mn, Cu, Zn) which makes these micronutrient stable and available during the growing period (Ikeh *et al*., 2012). The land was ploughed again to blend the organic matter with the soil particle and amended.

The land of plastic house was divided into ten lines due to the distribution system of the drip irrigation. Each line includes of 12 parts dividing into a line of (4 m × 0.75 m). The land was irrigated and doors were locked for a few days to disinfect the plastic house.

3.4. Cultural Practices

The seeds two cultivars Bellona F1 and Solo F1 were planted in plate pods (1 seed per pod) on February 15th 2018. The plates were then moved to the plastic house. The plastic house field was drip irrigated before transplanting. The cucumber seedling were planted on March 20th 2018 at distance of 30 cm between plants along the perforated hose line of drip irrigation system each seedling at the water hole.

3.5. Experimental Treatments

The experiment included foliar application of humic acid at three concentrations [E0 = spraying with (0) ml/L, E1 = spraying with 1 ml/L and E2 = spraying with (2) ml/L] and the seaweed extract (Seaforce 1) at three concentrations [E0 = spraying with (0) ml/L, E2 =spraying with (2) ml/L and E4 = spraying with (4) ml/L]. Therefore, the study consisted of (18) treatments (2 × 3 × 3 = 18). Each treatment was replicated three times and each replicate was represented by three lines, each line (4×0.75 m^2) of 10 plants, with interspace of 30 cm between plants. The humic acid solution was prepared by mixing 1 and 2 milliliters of humic acid with 1 liter of tap water and the mixture was well-shake. The same preparation was true for Seaforce 1 solution by mixing 2 and 4 ml with 1 L tap water too. The prepared solutions were applied three times. The first spray was carried out on March 27th 2018 with ten days' interval between each spray.

3.6. Experimental Design and Analysis

The experiment treatments were arranged in a factorial Randomized Complete Block design (RCBD) with three factors. Cucumber cultivars were main factor, seaweed extract Seaforce 1 (0.5-1% N, 6-9% P_2O_5, 21-24% K_2O, 6-9% Alganic acid, 0.4-1.6% CaO, 0.06% Mg, 1.0 -1.5% S, 0.15-0.3% Fe, 4% amino acid, 40-50% organic matter and 9-11% pH) as sub factor and humic acid (12% humic acid, 3% fulvic acid and 3% K_2O) was considered as sub-sub factor The differences between various treatment means were tested with Duncan multiple range test at 5% level. The data were analyzed using (SAS 2007) program.

3.7. Measurements

An internal line of plants in plastic house has been used for measuring all vegetative growth and yield parameters and the external lines of plants were exceptional for guard plants purpose.

3.7.1. Vegetative Growth Characters

3.7.1.1. Number of Leaves Plant^{-1}

At the end of the season, the number of leaves.plant-1 was counted form four plants in each experimental unit and averaged to record number of leaves per plant.

3.7.1.2. Vine Length (cm)

The vine length was measured from the contact point between the stem and the soil surface till the upper growing point of 4 plants in each experimental unit and averaged.

3.7.1.3. Leaf Area plant^{-1} (cm^2)

The measurement of leaf area per plant was carried out at eight harvests. The leaf area meter was used to estimate the leaf area of two physiologically completed leaves from each of the four plants in the experimental unit. Then the average was measured.

3.7.1.4. Leaf Chlorophyll Content (SPAD)

The chlorophyll content of leaf was measured after 45 days of transplanting from four plants in each experimental unit with the help of chlorophyll meter (SPAD-502, Konica Minolta).

3.7.1.5. Dry Matter Percentage of Vegetative Growth

After removal of fruits and roots, four plants have been chosen from each experimental unit. Then The plants were weighted for estimation of the fresh weight using the balance, after that the plants were taken and put in electrical oven at 70C0 for 48 hours until stabilization of the weight and ultimately the dry weight of the plant was determined (AL Sahaf, 1989). The percentage of dry matter was measured by the following equation:

$$Dry\ matter\ \% = \frac{Dry\ weight\ of\ vegetative\ growth}{Fresh\ weight\ of\ vegetative\ growth} \times 100$$

3.7.2. Mineral Contents in Leaves

For nutrient analyses, samples were collected from leaves randomly from plants in each experimental unit during the flowering stage. The leaves were cleaned and washed and dried in electric oven at 70 C^0 for 48 hours (Al –Sahaf, 1989). The leaves were ground in an electric grinder and 0.5 mg was weighed as standard weight from each grounded sample. The digestion of the standard sample was conducted by use of concentrated sulphuric acid and perchloric acid. After digestion process the prepared solution was ready for nutrient analysis.

3.7.2.1. Nitrogen Percentage (%)

The total nitrogen percentage was measured according to modified method of Kjeldahl and the analysis was done by use of Microkjeldahl instrument (A.O.A.C., 1980) that cited by Black (1965).

3.7.2.2. Phosphorus Percentage (%)

The measurement of phosphorus percentage (%) in leaves was carried out according to colorimetric methods and the spectrophotometer was used (Matt, 1970).

3.7.2.3. Potassium Percentage (%)

Potassium percentage (%) was measured according to flame method by using Flame photometer instrument (A.O.A.C., 1970; Al -Sahaf, 1989).

3.7.3. Yield Measurements

3.7.3.1. Yield Quantitative Characters

Harvesting of fruits was done three to four times per week and the following characters were evaluated:

3.7.3.1.1. Number of Fruits Plant

Four plants from each experimental unit were chosen for accounting the number of fruit per plant. The process begun from the first harvest and continued until the end of the growing season (25 harvests) and the following equation was used for calculation of number of fruits per plant:

$$Fruit\ /plant = \frac{Total\ fruit\ number/experiment\ unit}{Plant\ number\ in\ each\ experimental\ unit}$$

3.7.3.1.2. Average Weight of Fruit (g)

The measurement of average weight of fruit was performed at each harvest through dividing the weighing yield of each experimental unit by the fruit number in each experimental unit multiplied by one thousand (1000) as shown below:

$$\text{Average fruit weight (g)} = \frac{\text{Yield of experiment unit (kg)}}{number\ of\ fruits\ of\ experimenrtal\ unit} \times 1000$$

3.7.3.1.3. Early Yield ($g.plant^{-1}$)

The early yield was represented by the first three harvests.

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

Yield per plant was determined by calculation of the total yield of experimental unit divided by the number of plants in the experimental unit as illustrated below:

$$Plant\ yield\ (kg/\ plant)\ = \frac{Total\ yield\ of\ experimental\ unit\ (kg)}{Number\ of\ plant\ in\ experimental\ unit}$$

3.7.3.1.5. Yield (kg.m^2)

The measurement of average weight of fruit was performed at each harvest through dividing the weighing yield of each experimental unit by the fruit number in each experimental unit multiplied by one thousand (1000) as shown below:

$$\text{Yield kg . m2} = \frac{Yield\ of\ experimental\ unit\ (kg)}{Area\ of\ experimental\ unit} x1000$$

3.7.3.2. Yield Qualitative Characters

3.7.3.2.1. Fruit Diameter (cm)

The fruit diameter was calculated from twelve randomly selected fruits in each experimental unit using the vernier equipment and average.

3.7.3.2.2. Fruit Length (cm)

The measurement of Fruit length was performed through use of standard bar and the process was done on twelve fruits in each experimental unit then the average was counted.

3.7.3.2.3. Total Soluble Solids (%TSS)

The total soluble solids were measured in the juice through using hand Refracto- meter apparatus and four fruits from each experiment unit have been taken for this purpose (A.O.A.C, 1980).

4. RESULTS

4.1. Vegetative Growth Characters

4.1.1. Plant length

Data in Table 4.1 showed that the seaweed extract, humic acid, cultivar and their interactions significantly influenced plant length. Plants receiving 2 ml/L humic acid had the highest plant length (310.80 cm) compared with the rest of the concentrations. The Solo F1 cultivar plants possessed the highest plant length compared to Bellona F1 cultivar. Concerning seaweed extract effect, the maximum plant length was accounted for 4ml/L Seaforce1 solution in comparison with control and 2 ml/L.

The humic acid × cultivar interaction significantly affected plant length and the peak plant length was observed for Solo F1 plants with 2 ml/L of humic acid compared to the other treatments. The interaction of seaweed extract and cultivar exhibited prominent effect on plant length with higher plant length belonged to Bellona F1 cultivar plants with 4 ml/L Seaforce1 compared with other treatments. The humic acid × seaweed extract significantly enhanced plant length and 4 ml/L of Seaforce1 and 2 ml/L of humates resulted in the longest plant length (318.89 cm) in comparison with other concentrations (Table 4.1 and Figure 4.1).

Regarding the triple interaction between treatments, the supreme plant length (321.89 cm) was measured for Solo F1 plants treated with 1 ml/L and 4 ml/L of humic acid and Seaforce1 respectively as compared to Bellona F1 plants and other doses of biostimulants.

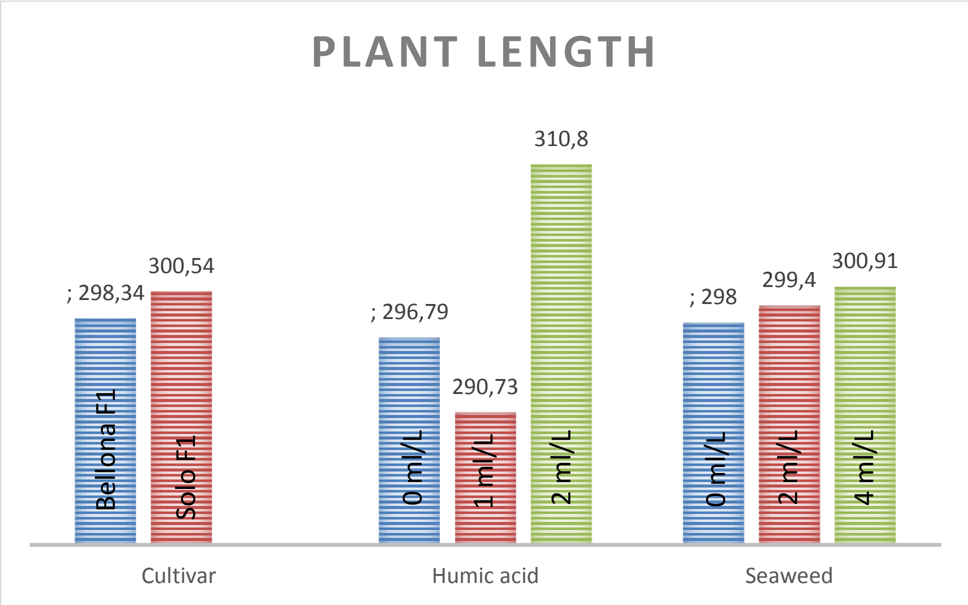

Figure 4.1. The effect of HA and SWE on plant length

Table 4.1. Effect of HA, SWE and their interactions on plant length (cm) of two cucumbers cultivars*

Cultivar	Humic acid ml/L	Seaweed extract (ml/L)			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	286.81 q	291.19 n	302.49 e	293.50 e	298.34 b
	1	298.04 k	289.69 o	276.54 r	288.09 f	
	2	301.56 g	316.89 b	321.89 a	313.45 a	
Solo F1	0	301.45 h	296.80 l	302.02 f	300.09 c	300.54 a
	1	299.91 j	293.55 m	286.66 p	293.37 d	
	2	300.26 i	308.29 d	315.89 c	308.15 b	
Seaweed		298.00 c	299.40 b	300.91 a	Humic acid	
Cultivar × Seaweed	Bellona F1	295.47 f	299.26 e	300.31 c		
	Solo F1	300.54 b	299.55 d	301.52 a		
Humic × Seaweed	0	294.13 g	293.99 f	302.25 c	296.79 b	
	1	298.97 e	291.62 h	281.60 i	290.73 c	
	2	300.91 d	312.59 b	318.89 a	310.80 a	

*Means sharing the same letters within a column or row are not significantly different from each other according to Duncan's multiple ranges test at 5% probability level.

4.1.2. Number of Leaves Plant^{-1}

Results in Table 4.2 revealed no significant difference between humic acid level of 1 and

2 ml/L in term of number of leaves per plant with significant difference from the control 0 ml/L treatment. The same thing was true for the cultivar which did not differ from each other for number of leaves per plant. The seaweed extract impact on number of leaves per plant was distinguished from the two previous treatments effect and the maximum average of number of leaves per plant (49.77) in comparison with other treatments.

The binary interaction between humic acid and cultivar significantly impacted number of leaves per plant and the maximum value of leaves number per plant was measured for plants from Bellona F1 cultivar receiving 2 ml/L humic acid when compared with Bellona F1 cultivar and other treatments. The interaction between seaweed extract and cultivar also significantly improved leaves number per plant and plants from cultivar Solo F1 sprayed with 4 ml/L Seaforce1 possessed the highest number o f leaves per plant. On the other hand, the dual interference between the two biostimulants showed a significant influence on number of leaves per plant with the highest average (53.44) calculated for plants given 2 ml/L of humic acid and 4 ml/L of Seaforce1as illustrated in Table 4.2 and Figure 4.2.

The three-way interaction prominently enhanced number of leaves per plant with the maximum number of leaves per plant accounted in Solo F1 cultivar sprayed with 2 ml/L humic acid and 4 ml/L Seaforce1 in comparison with control and other treatments as shown in Table 4.2 and Figure 4.2.

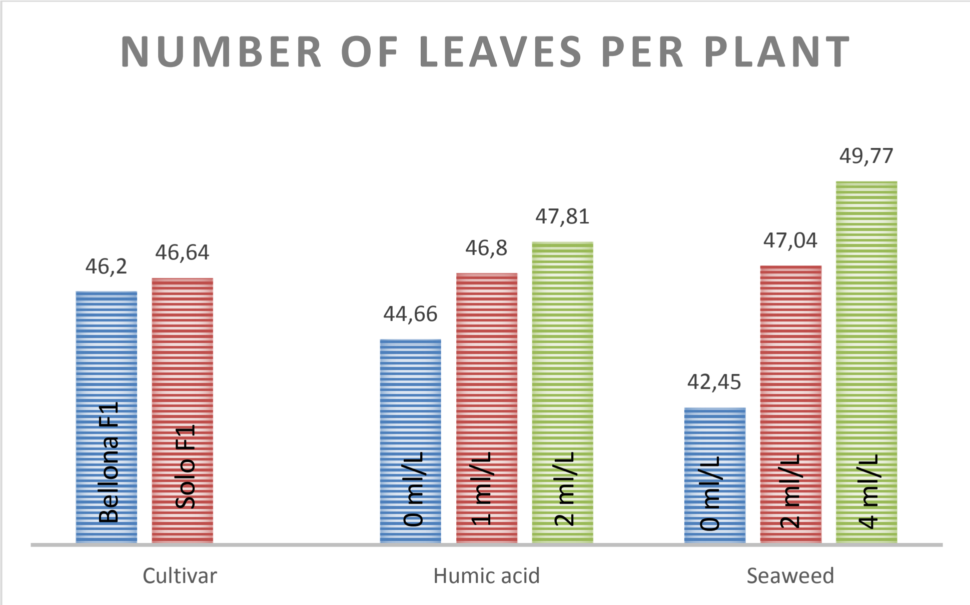

Figure 4.2. The effect of HA and SWE on number of leaves per plant

Table 4.2. Effect of HA, SWE and their interactions on number of leaves per plant of cucumber cultivars*

Cultivar	Humic acid ml/L	Seaweed extract (ml/L) 0	2	4	Cultivar × Humic	Cultivar
Bellona F1	0	38.12 f	47.29 b-d	47.33 b-d	44.25 d	46.20 a
	1	43.85 e	48.20 bc	45.92 c-e	45.99 bc	
	2	43.95 e	48.41 bc	52.76 a	48.37 a	
Solo F1	0	38.04 f	47.46 b-d	49.69 b	45.06 cd	46.64 a
	1	46.30 b-e	47.70 b-d	48.82 bc	47.61 ab	
	2	44.43 de	43.20 e	54.12 a	47.25 ab	
Seaweed		42.45 c	47.04 b	49.77 a	Humic acid	
Cultivar × Seaweed	Bellona F1	41.97 d	47.97 b	48.67 b		
	Solo F1	42.93 d	46.12 c	50.88 a		
Humic × Seaweed	0	38.08 e	47.38 bc	48.51 b	44.66 b	
	1	45.08 d	47.95 bc	47.37 bc	46.80 a	
	2	44.19 d	45.80 cd	53.44 a	47.81 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

4.1.3. Chlorophyll Percentage (%)

The obtained data indicated no significant variation between cucumber plants in term of total chlorophyll percentage in leaves of both cultivars. On contrary, the effect of humic acid was significant on chlorophyll content in leaves with the supreme value measured for plants supplied with 2 ml/L of humic acid which was (55.14%) when compared with control and 4 ml/L of humic acid. Similar to cultivar effect, the seaweed extract influence did not show any significance among plants treated with the Seaforce1 extract in term of total percentage of chlorophyll (Table 4.3).

The interaction of cultivar and humic acid impact improved total chlorophyll percentage and plants from Solo F1Solo F1 cultivar treated with a level of 2 ml/Lof humates were super in chlorophyll content having a percentage of (55.52%) compared to the other cultivar and other treatments. The same effect had not been found in the interaction between cultivar and the seaweed extract with no variation among cucumber plants from both cultivars in regard to total chlorophyll percentage. The interaction between humic acid seaweed extract was premium in enhancement of chlorophyll content and Plants received humic acid and Seaforce1 contained ameliorated chlorophyll percentage as compared to control (0 ml/L).

The combined influence of the three treatment on total chlorophyll percentage was profound and the record of the highest chlorophyll percentage in leaves (59.73%) belonged to plants from Solo F1 cultivar given a dosage of 2 ml/L and 4 ml/L of humic acid and the seaweed extract Seaforce1 as seen in Table 4.3 and Figure 4.3.

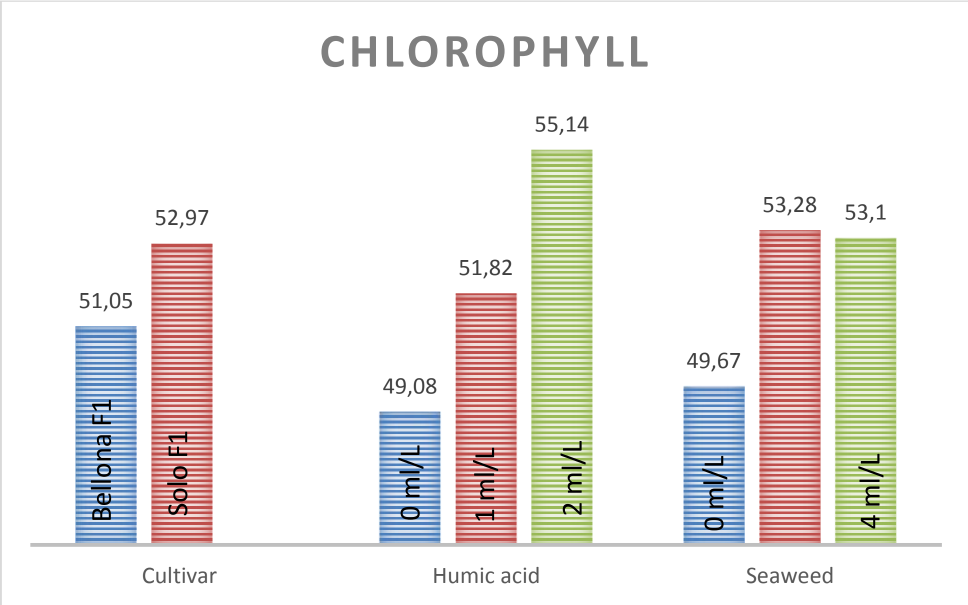

Figure 4.3. The effect of HA and SWE on chlorophyll

Table 4.3. Effect of HA, SWE and their interactions on chlorophyll percentage of two cucumbers cultivars*

Cultivar	Humic acid ml/L	Seaweed extract (ml/L)			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	43.40 b	51.07 ab	47.28 ab	47.25 b	51.05 a
	1	52.72 ab	50.18 ab	50.53 ab	51.14 ab	
	2	54.27 ab	56.05 ab	53.98 ab	54.77 ab	
Solo F1	0	45.78 ab	54.13 ab	52.82 ab	50.91 ab	52.97 a
	1	51.88 ab	51.35 ab	54.23 ab	52.49 ab	
	2	49.95 ab	56.88 ab	59.73 a	55.52 a	
Seaweed		49.67 a	53.28 a	53.10 a	Humic acid	
Cultivar × Seaweed	Bellona F1	50.13 a	52.43 a	50.60 a		
	Solo F1	49.21 a	54.12 a	55.59 a		
Humic × Seaweed	0	44.59 b	52.60 ab	50.05 ab	49.08 b	
	1	52.30 ab	50.77 ab	52.38 ab	51.82 ab	
	2	52.11 ab	56.47 a	56.86 a	55.14 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

4.1.4. Dry Matter (g)

It obvious in Table 4.4 that the treatments significantly increased dry matter of cucumber crop. A significant variation has been observed between plants of the two cultivars with supremacy for the Solo F1cultivar for which the maximum dry matter was recorded (17.87 g). Similar difference was recorded due to humic acid effect and the highest dry matter (18.28 g) was measured for plants applied with 2 ml/L of humic acid compared to control 4 ml/L and the other treatment 1 ml/L. the same results was seen in the seaweed extract influence on plants given Seaforce1 at level of 4 ml/L that possessed a dry matter of (18.45 g).

The combined effect of humic acid and cultivar was also significant on plant dry matter with the majority for plants from Bellona F1 cultivar sprayed with humic acid at level of 2 ml/Las compared to other treatments. The dual interaction between cultivar and seaweed extract significantly impacted plant dry matter and plants of Solo F1 cultivar received a dosage of 4 ml/L of Seaforce1 had the greatest dry matter value (18.47 g). About the influence of seaweed extract and humic acid, there was a significant difference between plants in term of dry matter plant treated with levels of 2 ml/L humic acid and 4 ml/L of Seaforce1 had the highest dry matter value (19.06 g) (Figure 4.4).

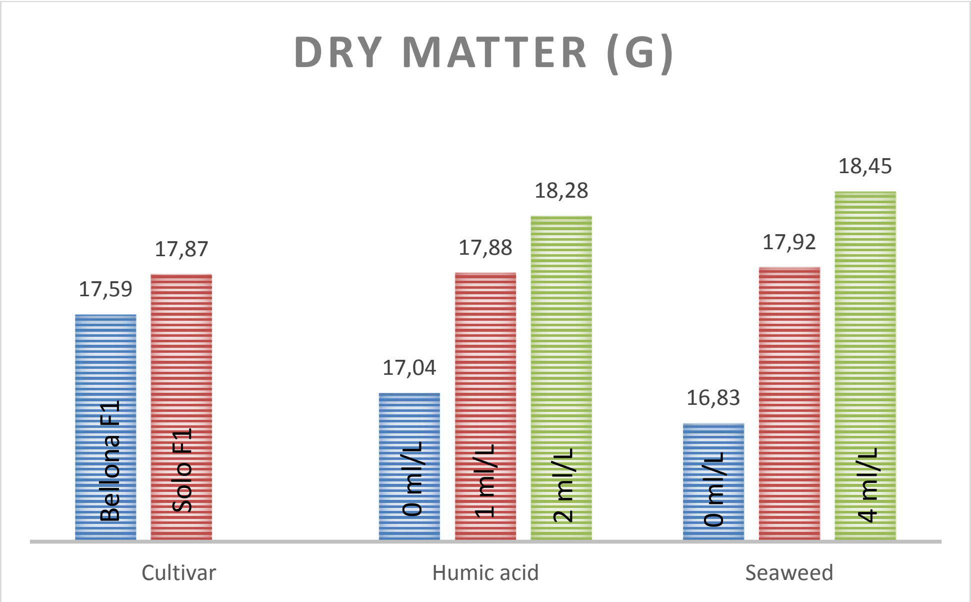

Figure 4.4. The effect of HA and SWE on dry matter (g)

Table 4.4. Effect of HA, SWE and their interactions on plant dry matter (g) of two cucumber cultivars*

Cultivar	Humic acid (ml/L)	Seaweed extract (ml/L)			Cultivar × Humic	Cultivar
		0	2	4		
Bellona	0	14.33 o	17.33 l	18.10 g	16.59 f	17.59 b
	1	17.22 m	18.20 e	18.00 h	17.81 d	
	2	17.50 k	18.44 d	19.22 a	18.39 a	
Solo F1	0	15.80 n	18.10 g	18.60 c	17.50 e	17.87 a
	1	18.00 h	17.95 i	17.90 j	17.95 c	
	2	18.12 f	17.50 k	18.90 b	18.17 b	
Seaweed		16.83 c	17.92 b	18.45 a	Humic acid	
Cultivar×Seaweed	Bellona	16.35 f	17.99 c	18.44 b		
	Solo F1	17.31 e	17.85 d	18.47 a		
Humic × Seaweed	0	15.07 i	17.72 g	18.35 b	17.04 c	
	1	17.61 h	18.08 c	17.95 e	17.88 b	
	2	17.81 f	17.97 d	19.06 a	18.28 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

There has been a significant improvement in plant dry matter attributed to the complicated effect of treatments (cultivar × humic acid× seaweed extract) which was conspicuous in plants from Bellona F1 cultivar supplied with concentrations of 2 ml/L and 4 ml/L of humic acid and Seaforce1 respectively that owned the maximum dry matter (19.22 g) in comparison with other treatments (see Table 4.4).

4.1.5. Leaf Area (cm^2)

The data listed down in Table 4.5 showed no significant differences among plants in concern to the cultivar factor effect. The influence of humic acid also resulted in no remarkable variations among plants that sprayed with different levels of humic acid. In contrast, the effect of the seaweed extract Seaforce1 made an increase in the leaf area of cucumber crop and plants treated with Seaforce1 at a concentration of 4 ml/L were superior to plants received the extract with other concentrations having a leaf area of (91.74 cm^2). Regarding the binary interactions, the cultivar interaction with humic acid caused no significant influence on leaf area of the crop. The opposite was true for interaction between cultivar and seaweed extract and the highest leaf area (92.61 cm^2) was recorded in plants from Solo F1cultivar provided with a dosage of 4 ml/L of Seaforce1comparing to the other cultivar and other treatments. A significant enhance was noticed in leaf area which attributed to the interaction between seaweed extract and humic acid with measuring the maximum leaf area (96.20 cm^2) for plants treated with humic acid at level of 2 ml/L and Seaforce1 at level of 4 ml/L as compared to plants received other treatments.

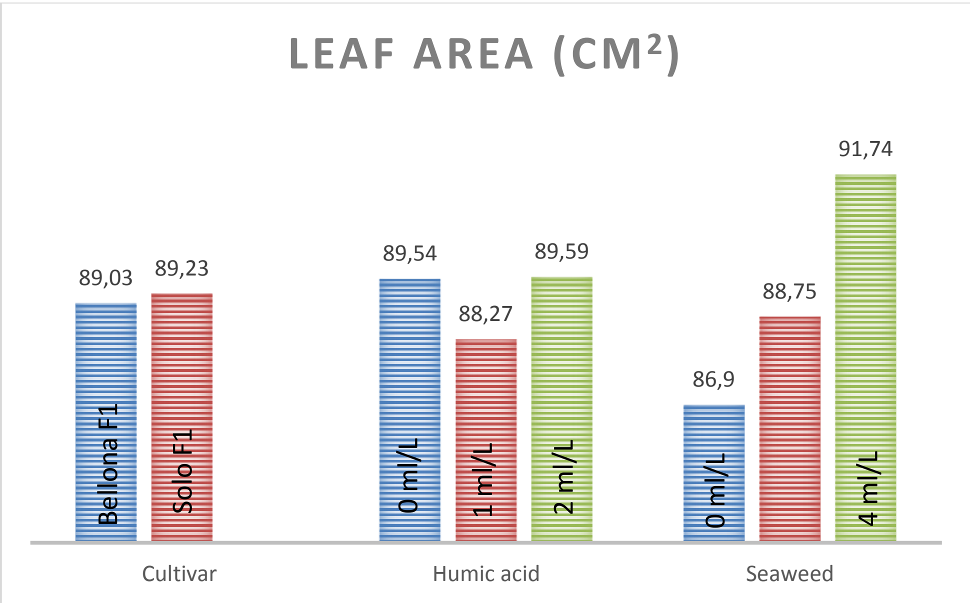

Figure 4.5. The effect of HA and SWE on leaf area (cm^2)

The leaf area was significantly influenced by the triple interaction (cultivar× humic acid× seaweed extract) and that was evident in cucumber plants belonged to Bellona F1 cultivar given humic acid at 2 ml/L and Seaforce1 at 4 ml/L that owned a leaf area of (96.35 cm^2) when comparing them with Bellona F1 cultivar and other various treatments as illustrated in Table 4.5 and Figure 4.5.

Table 4.5. Effect of HA, SWE and their interactions on plant leaf area of two cucumbers cultivars*

Cultivar	Humic acid (ml/L)	Seaweed extract (ml/L)			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	86.75 cd	89.83 a-d	91.08 a-d	89.22 a	89.03 a
	1	88.81 a-d	90.22 a-d	85.21 cd	88.08 a	
	2	85.61 cd	87.44 cd	96.35 a	89.80 a	
Solo F1	0	87.08 cd	89.36 a-d	93.17 a-c	89.87 a	89.23 a
	1	89.22 a-d	87.55 cd	88.60 a-d	88.46 a	
	2	83.94 d	88.12 b-d	96.05 ab	89.37 a	
Seaweed		86.90 b	88.75 b	91.74 a	Humic acid	
Cultivar × Seaweed	Bellona F1	87.06 b	89.16 ab	90.88 ab		
	Solo F1	86.75 b	88.34 ab	92.61 a		
Humic × Seaweed	0	86.92 bc	89.59 bc	92.12 ab	89.54 a	
	1	89.02 bc	88.89 bc	86.91 bc	88.27 a	
	2	84.78 c	87.78 bc	96.20 a	89.59 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

4.2. Mineral Content in Leaves

4.2.1. Nitrogen percentage (N %)

The trial data (Table 4.6) showed that the N in the leaves of Bellona F1 cv. was higher (2.67%) than that of Solo F1 cultivar. The HA application significantly increased N with the higher percentage 2.71% accounted for plants treated with HA in comparison with other treatments. The seaweed extract factor did the same effect on N and the maximum percentage was measured for plants received (Seaforce1) which was 2.70%.

The results also unveiled a significant influence of (cultivar × humic acid) interaction on N in leaves of cucumber and the peak value (2.98%) was measured in the leaves of plants belonging to Bellona F1 cultivar applied with 2 ml/L of Ha as compared to Solo F1 plants and other treatments. Regarding the (seaweed extract 8 cultivar) interaction, it was significant on N (%) in plants from Bellona F1 cultivar sprayed with 4 ml/L SWE with the highest percentage of (2.94%) being recorded. The dual interaction between the two biostimulants possesses the same positive effect on N (%) of leaves and plants taken a dosage of 2 ml/L of HA and 4 ml/L of SWE contained the maximum (3.02%) when comparable with other treatments (Table 4.6 and Figure 4.6).

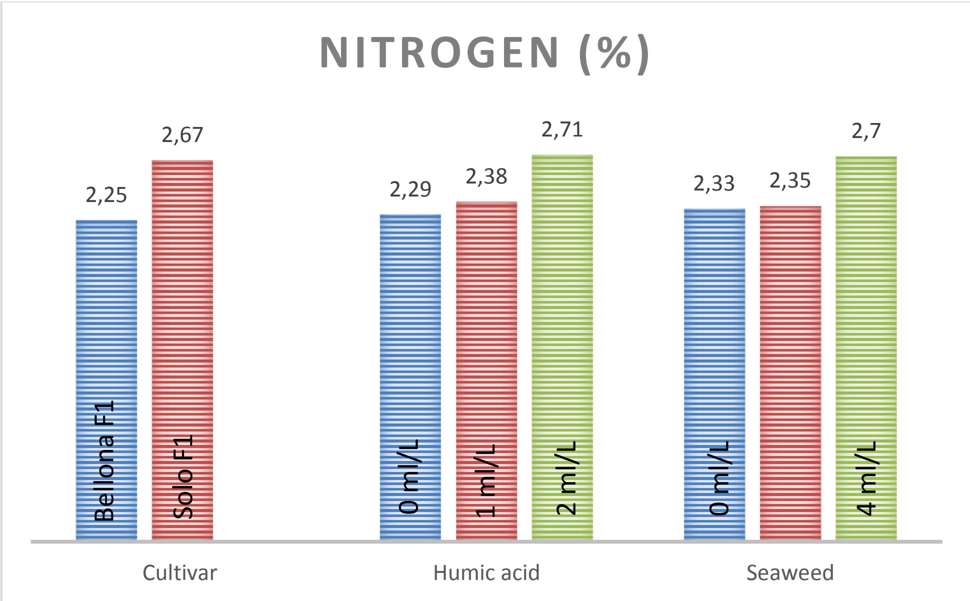

Figure 4.6. The effect of HA and SWE on nitrogen

Table 4.6. Effect of HA, SWE and their interactions on nitrogen percentage of two cucumber cultivars*

Cultivar	Humic acid (ml/L)	Seaweed extract (ml/L)			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	1.90 h	2.33 g	1.83 h	2.02 d	2.25 b
	1	1.93 h	2.33 g	2.63 ef	2.30 c	
	2	2.53 fg	1.83 h	2.93 a-d	2.43 b	
Solo F1	0	1.80 h	2.87 b-d	2.98 a-c	2.55 b	2.67 a
	1	2.73 d-f	1.93 h	2.73 d-f	2.47 b	
	2	3.05 ab	2.80 c-e	3.10 a	2.98 a	
Seaweed		2.33 b	2.35 b	2.70 a	Humic acid	
Cultivar × Seaweed	Bellona F1	2.12 c	2.17 c	2.47 b		
	Solo F1	2.53 b	2.53 b	2.94 a		
Humic × Seaweed	0	1.85 f	2.60 c	2.41 d	2.29 c	
	1	2.33 d	2.13 e	2.68 bc	2.38 b	
	2	2.79 b	2.32 d	3.02 a	2.71 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

The complex effect of the three factors on N (%) of cucumber leaves was as previous interactions and plants from Bellona F1 cultivar that had humic acid with level of 2 ml/L plus seaweed extract with level of 4 ml/L owned the highest percentage (3.10%) of N nutrient when compared with other treatments as conspicuous in Table 4.6.

4.2.2. Phosphorus Percentage (P %)

The phosphorus percentage did not significantly influence by cultivar factor. In contrast, the P (%) in leaves significantly impacted by HA with measuring the highest value (0.50%) for plants treated with 2 ml/L of humates as compared to other treatments. Similar to HA, SWE application had a significant influence on P (%) and plant foliar sprayed with SWE possessed the maximum percentage (0.46%) as shown in Table 4.7. The cultivar together with humic acid caused a significant increase in (P %) of leaves and the Solo F1 cultivar plants treated with the level of 2 ml/L of humic acid were predominant in having the biggest (0.51%) mineral percentage. The same influence was recorded according to interaction between seaweed extract and cultivar and plants from the cultivar Solo F1 supplied with (Seaforce1) at concentration of 4 ml/L contained the highest percentage (0.48%). Concerning the binary interaction between humic acid and seaweed extract, the biggest P (%) was measured in leaves of cucumber plants received humic acid at dosage of 2 ml/L and the seaweed extract (Seaforce1) at dosage of 4 ml/L which was (0.55%) in comparison with control and the other dosage.

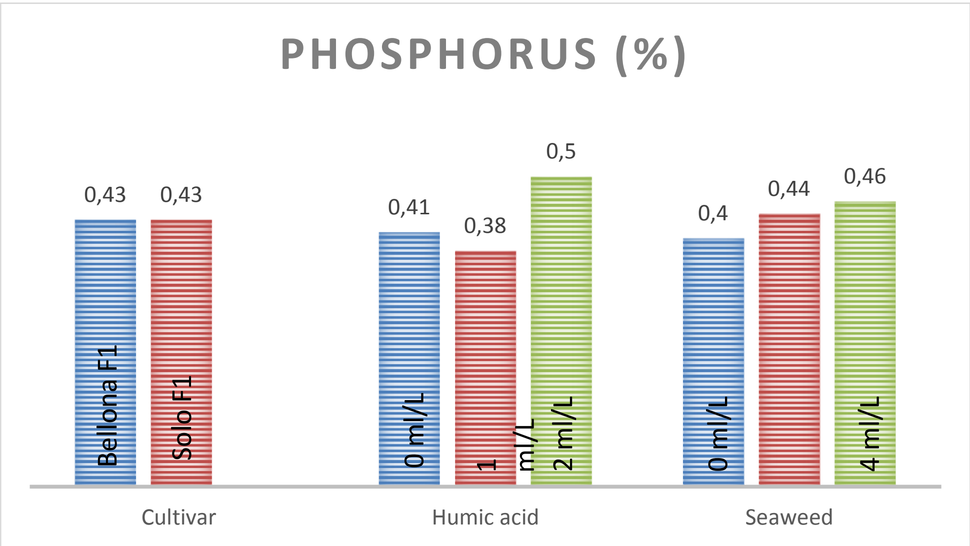

Figure 4.7. The effect of HA and SWE on phosphorus

Table 4.7. Effect of HA, SWE and their interactions on phosphorus percentage of two cucumber cultivars*

Cultivar	Humic acid (ml/L)	Seaweed extract (ml/L)			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	0.33 e	0.43 b-e	0.53 ab	0.43 bc	0.43 a
	1	0.39 c-e	0.35 e	0.33 e	0.36 c	
	2	0.45 a-e	0.50 a-c	0.58 a	0.51 a	
Solo F1	0	0.37 de	0.38 c-e	0.45 a-e	0.40 c	0.43 a
	1	0.41 b-e	0.46 a-e	0.36 e	0.41 c	
	2	0.43 b-e	0.50 a-d	0.52 a-c	0.48 ab	
Seaweed		0.40 b	0.44 ab	0.46 a	Humic acid	
Cultivar × Seaweed	Bellona F1	0.39 b	0.43 ab	0.48 a		
	Solo F1	0.40 b	0.45 ab	0.44 ab		
Humic × Seaweed	0	0.35 d	0.41 cd	0.49 a-c	0.41 b	
	1	0.40 cd	0.40 cd	0.34 d	0.38 b	
	2	0.44 bc	0.50 ab	0.55 a	0.50 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

The P (%) was also significantly ameliorated by the triple interaction (seaweed extract × humic acid × cultivar). Plants of Solo F1 cultivar that applied with humic acid at level of 2 ml/L along with the (Seaforce1) at level of 4 ml/L had the highest percentage (0.58%) of (P) as compared with the other cultivar and other treatments as illustrated in Table 4.7 and Figure 4.7.

4.2.3. Potassium percentage (K %)

Data in Table 4.8 revealed significant differences between the two cultivar relating to K (%). The Bellona F1 plants contained the maximum percentage (2.31%) of K as compared to Solo F1 cultivar. The results showed a significant improvement in K (%) of leaves due to application of humic acid with the maximum value (2.35%) calculated for plants treated with humic acid at level of 2 ml/L. seaweed extract factor possessed the same influence on K (%). Plants delivered (Seaforce1) at level of 4 ml/L had the highest percentage (2.40%) of K.

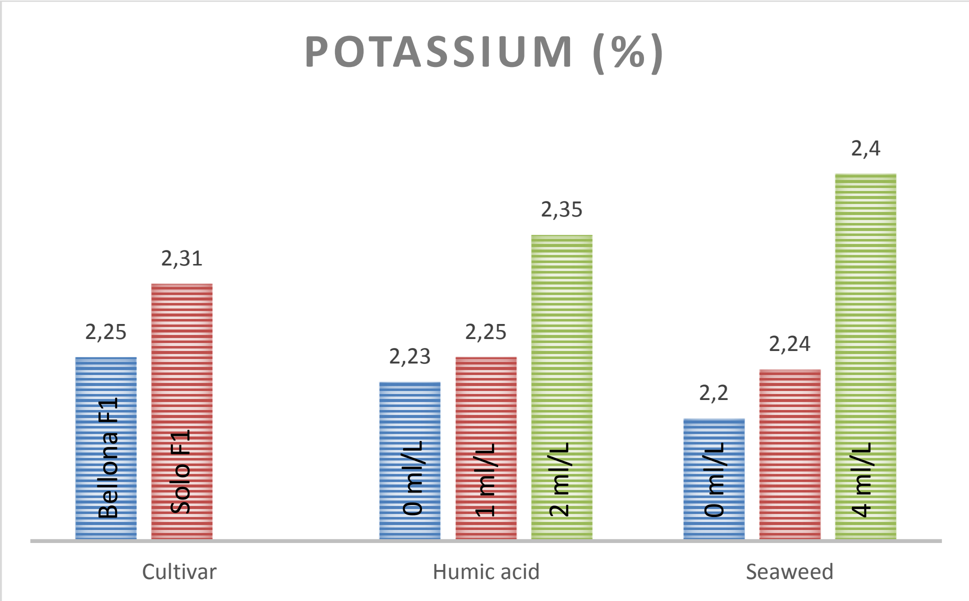

Figure 4.8. The effect of HA and SWE on potassium

Table 4.8. Effect of HA, SWE and their interactions on potassium percentage of two cucumber cultivars*

Cultivar	Humic acid	Seaweed extract 0	Seaweed extract 2	Seaweed extract 4	Cultivar × Humic	Cultivar
Bellona F1	0	2.18 c	2.34 ab	2.06 c	2.19 c	2.25 b
	1	2.03 c	2.38 ab	2.44 ab	2.28 b	
	2	2.34 ab	1.90 c	2.55 a	2.26 bc	
Solo F1	0	1.92 c	2.39 ab	2.51 a	2.27 bc	2.31 a
	1	2.28 b	2.03 c	2.32 ab	2.21 bc	
	2	2.44 ab	2.37 ab	2.51 a	2.44 a	
Seaweed		2.20 b	2.24 b	2.40 a	Humic acid	
Cultivar × Seaweed	Bellona F1	2.18 d	2.21 cd	2.35 ab		
	Solo F1	2.21 cd	2.27 bc	2.45 a		
Humic × Seaweed	0	2.05 c	2.37 b	2.29 bc	2.23 b	
	1	2.15 c	2.21 c	2.38 b	2.25 b	
	2	2.39 ab	2.14 c	2.53 a	2.35 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

The influence of cultivar and humic acid was significant in Bellona F1 plant treated with humic acid at concentration of 2 ml/L which had the maximum percentage (2.44%) of K in their leaves. A significant increase in K (%) was recorded due to interaction between cultivar and seaweed extracts and the peak value (2.45%) was measured in leaves of plants from Bellona F1 cultivar that sprayed with the seaweed extract (Seaforce1) at concentration of 4 ml/L as compared to other treatments. The dual interaction between the two bio stimulants (seaweed extract × humic acid) also significantly improved K (%) in leaves. The maximum percentage (2.53%) was accounted for plants treated with 2 ml/L and 4 ml/L of humic acid and seaweed extract respectively.

The K (%) in leaves recorded a significant amelioration due to the triple interaction between factors and the best percentage (2.55%) was estimated for plants from Solo F1 cultivar that had humic acid with level of 2 ml/L and the extract (Seaforce1) with level of 4 ml/L as seen in Table 4.8 and Figure 4.8.

4.3. Yield Quantitative Characters

4.3.1. Number of Fruit Plant $^{-1}$

The number of fruit per plant did no significantly influenced by cultivar factor as demonstrated in Table 4.9. The effect of humic acid factor exhibited a significant enhancement in number of fruit per plant. The greatest average of number of fruits per plants (99.22 g) returned to plant treated with humic acid at concentration of 2 ml/L as compared to the two other treatments. No significant differences were found in cucumber plants in term of effect of seaweed extract factor on fruit number per plants.

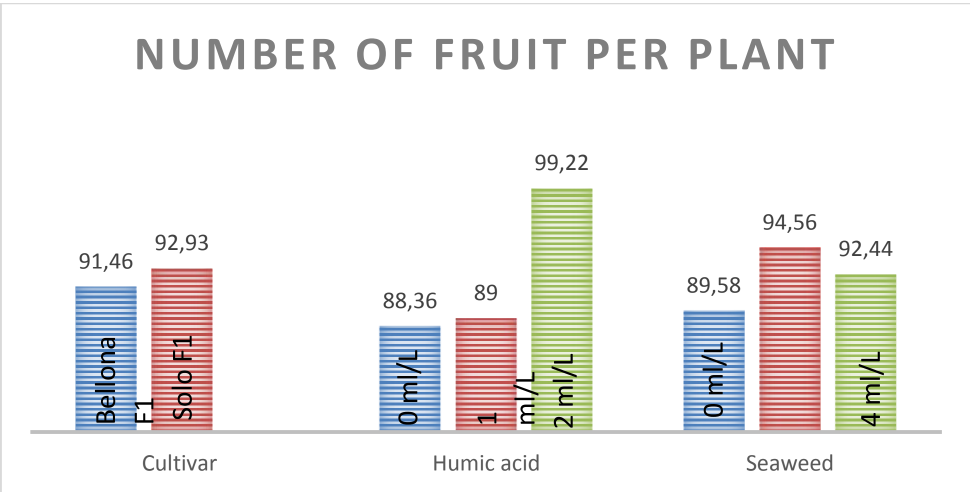

Figure 4.9. The effect of HA and SWE on number of fruits per plant

The impact of cultivar along with humic acid did not show any significant improvement in fruit number per plant. The same results were seen due the interaction between cultivar and the seaweed extract factors which did not prominently increased fruit number per plant. In case of dual interaction (seaweed extract × humic acid) a significant enhance was recorded in fruit number per plant with measurement of the highest average of number of fruit per plant (106.67) for plants supplied with biostimulants at concentration of 2 ml/L of humic acid and 4 ml/L of Seaforce1 in comparison with other treatments.

Table 4.9. Effect of HA, SWE and their interactions on fruit number/ plant of two cucumber cultivars*

Cultivar	Humic acid	Seaweed extract			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	75.50 c	99.33 ab	92.33 a-c	89.06 a	91.46 a
	1	87.33 a-c	93.67 a-c	80.67 bc	87.22 a	
	2	95.00 a-c	91.00 a-c	108.33 a	98.11 a	
Solo F1	0	83.67 a-c	92.00 a-c	87.33 a-c	87.67 a	92.93 a
	1	91.67 a-c	99.67 ab	81.00 bc	90.78 a	
	2	104.33 ab	91.67 a-c	105.00 ab	100.33 a	
Seaweed		89.58 a	94.56 a	92.44 a	Humic acid	
Cultivar × Seaweed	Bellona F1	85.94 a	94.67 a	93.78 a		
	Solo F1	93.22 a	94.44 a	91.11 a		
Humic × Seaweed	0	79.58 c	95.67 ab	89.83 a-c	88.36 b	
	1	89.50 a-c	96.67 ab	80.83 bc	89.00 b	
	2	99.67 a	91.33 a-c	106.67 a	99.22 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

A significant amelioration was remarkable in fruit number per plants regarding to the influence of the three factors. The average of fruit number per plant was maximum (108.33) in plants of Bellona F1 cultivar applied with humic acid at rate of 2 ml/L along with Seaforce1 extract at rate of 4 ml/L as shown in Table 4.9 and Figure 4.9.

4.3.2. Single Weight of Fruit (g)

The earned data indicated a significant difference between the two cultivars relating to single weight of fruit and the Solo F1 cultivar surpassed the Bellona F1 cultivar in single fruit weight (61.44 g). The effect of humic acid factor on fruit single weight was no as significant as cultivar factor. That was not observed in case of seaweed extract factors and the premium single weight of fruit (62.54 g) was measured for cucumber plants foliar sprayed with Seaforce1 at concentration of 4 ml/L as compared to other doses (Table 4.10).

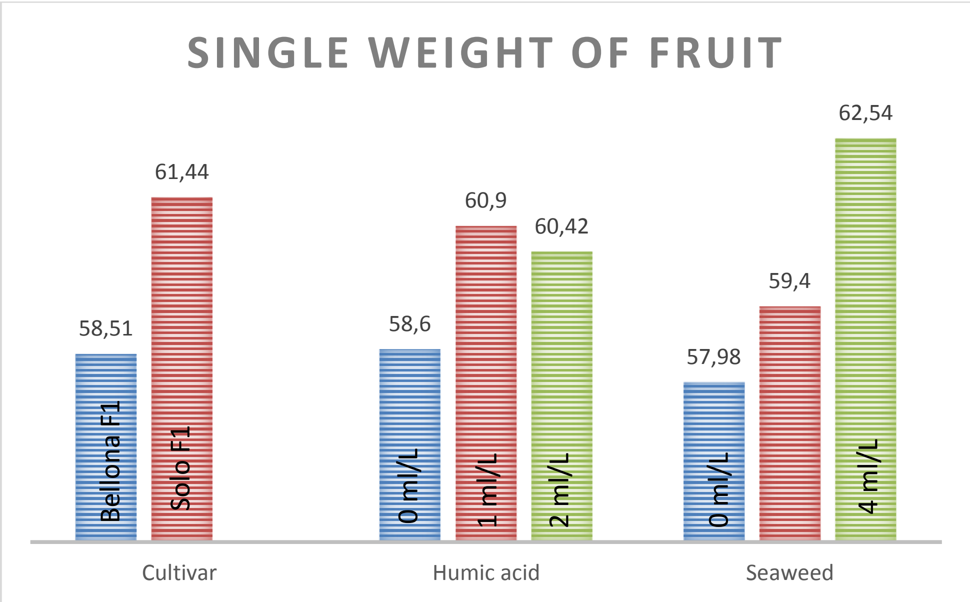

Figure 4.10. The effect of HA and SWE on single weight of fruit

The single weight of fruit was not significantly increased by interaction of cultivar and humic acid factors. The fruit single weight was significantly improved due to binary interaction between cultivar and seaweed extract factors and the peak value of single weight of fruit (63.73 g) was accounted for plants from Solo F1 cultivar treated with a level of 4 ml/L of Seaforce1 compare to Bellona F1 cultivar and the remained treatments. The same effect was found in the interaction between humic acid and seaweed extract factors calculating the greatest single weight of fruit (65.29 g) in plants supplied with humic acid at level of 4 ml/L and Seaforce1 at level of 4 ml/L.

Table 4.10. Effect of HA, SWE and their interactions on single fruit weight of two cucumber cultivars*

Cultivar	Humic acid	Seaweed extract			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	51.06 c	53.28 c	59.86 a-c	54.73 b	58.51 b
	1	58.37 a-c	57.73 bc	64.55 ab	60.22 a	
	2	63.08 ab	59.01 a-c	59.65 a-c	60.58 a	
Solo F1	0	59.59 a-c	61.81 ab	65.99 a	62.46 a	61.44 a
	1	57.10 bc	61.64 ab	66.02 a	61.59 a	
	2	58.68 a-c	62.91 ab	59.19 a-c	60.26 a	
Seaweed		57.98 b	59.40 b	62.54 a	Humic acid	
Cultivar × Seaweed	Bellona F1	57.50 bc	56.67 c	61.35 ab		
	Solo F1	58.46 bc	62.12 ab	63.73 a		
Humic × Seaweed	0	55.33 c	57.55 bc	62.92 ab	58.60 a	
	1	57.74 bc	59.68 bc	65.29 a	60.90 a	
	2	60.88 a-c	60.96 a-c	59.42 bc	60.42 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

A significant enhance in single weight of fruits was indicated in attribution to the effect of the triple interaction of the factors (cultivar × humic acid × seaweed extract). The maximum single weight of fruit (66.02 g) was measured in plants of Solo F1 cultivar delivered humic acid at the concentration 2 ml/L and Seaforce1 at the concentration 4 ml/L in comparison with the other treatments as clarified in Table 4.10 and Figure 4.10.

4.3.3. Early Yield (kg.plant^{-1})

Data in Table 4.11 revealed that the influence of cultivar factor was significant on early yield of cucumber crop. The Solo F1 cultivar was superior to the Bellona F1 cultivar in having the best early yield per plant (1.16 kg). The same improved early yield was measured for plants applied with humic acid at level of 2 ml/L calculating an early yield of (1.11 kg) as compared to other treatments. The third factor (Seaforce1) single influence was profound on early yield accounting the highest early yield (1.10 kg) from application of Seaforce1at level of 4 ml/L in compare with other levels. The early yield of cucumber was also significantly affected by dual interaction (cultivar × humic acid) and the greatest early yield was accounted for Bellona F1 cultivar plants treated with

2 ml/L of humic acid (1.22 kg). Similarly, the cultivar along with seaweed extract led to remarkable increase in early yield and that was apparent in plants from Bellona F1 cultivar given Seaforce1 at a concentration 2 ml/L which possessed the highest early yield (1.29 kg). Concerning the interaction between the two bio stimulants (humic acid × Seaforce1), a significant amelioration in early yield was recorded in application of humic acid at 2 ml/L and Seaforce1 at 4 ml/L measuring an early yield of (1.28 kg).

The interaction of factors (cultivar × humic acid × seaweed extract) humic acid did not significantly affected early yield with the calculation of the maximum early yield (1.47 kg) in Solo F1 cultivar plants treated with humic acid at level of 4 ml/L and Seaforce1 at level of 2 ml/L as shown in Table 4.11 and Figure 4.11.

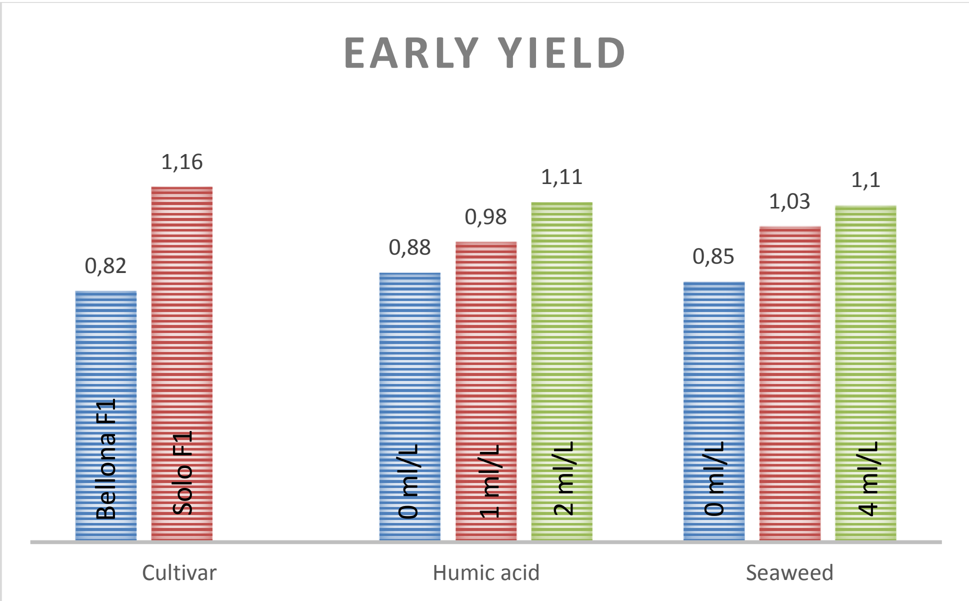

Figure 4.11. The effect of HA and SWE on early yield

Table 4.11. Effect of HA, SWE and their interactions on early yield of two cucumber cultivars*

Cultivar	Humic acid	Seaweed extract			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	0.55 ef	0.81 c-e	0.84 b-e	0.70 b	0.82 b
	1	0.98 a-d	0.40 f	0.90 b-e	0.76 b	
	2	0.57 d-f	1.11 a-c	1.33 a-c	1.01 ab	
Solo F1	0	0.56 d-f	1.47 a	1.19 a-c	1.07 a	1.16 a
	1	1.36 ab	1.17 a-c	1.08 a-d	1.20 a	
	2	1.19 a-c	1.22 a-c	1.23 a-c	1.22 a	
Seaweed		0.85 b	1.03 ab	1.10 a	Humic acid	
Cultivar × Seaweed	Bellona F1	0.67 c	0.77 bc	1.03 ab		
	Solo F1	1.04 ab	1.29 a	1.17 a		
Humic × Seaweed	0	0.50 d	1.14 a-c	1.02 a-c	0.88 b	
	1	1.17 ab	0.78 cd	0.99 a-c	0.98 ab	
	2	0.88 b-d	1.17 ab	1.28 a	1.11 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

4.3.4. Yield ($kg.m^2$)

The yield ($kg.m^2$) for Bellona F1 cultivar did not significantly varied from that for Solo F1 cultivar (Table 4.12). The humic acid treatments significantly influenced yield with the maximum yield accounted for plants received humic acid at level of (28.48 kg). Likewise, the seaweed extract significantly improved yield ($kg.m^2$) measuring the highest yield (27.35 kg) for plants sprayed with the seaweed extract (Seaforce1) at concentration of 4 ml/L.

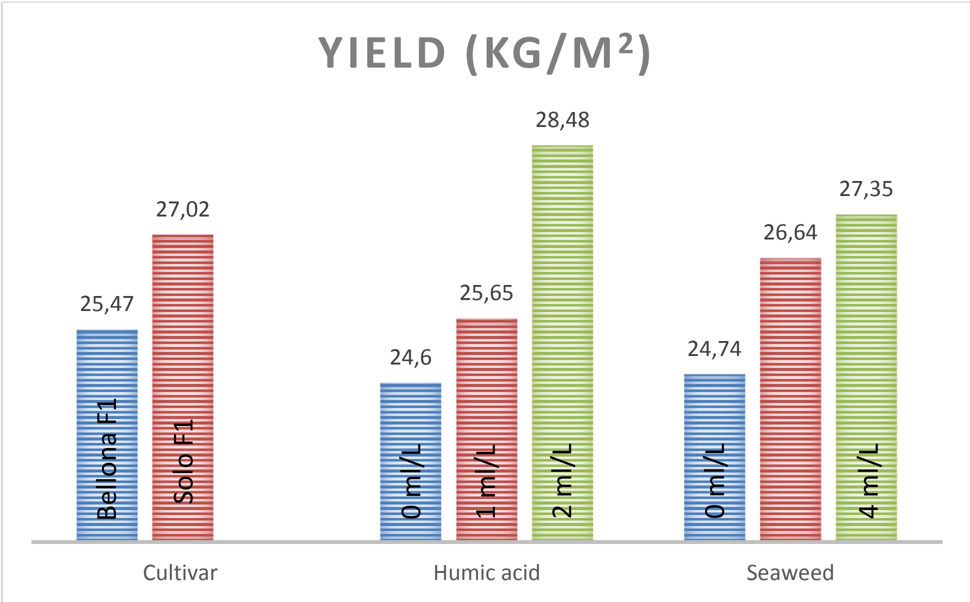

Figure 4.12. The effect of HA and SWE on yield (kg/m^2)

Table 4.12. Effect of HA, SWE and their interactions on yield (kg.m^2) of two cucumber cultivars*

Cultivar	Humic acid	Seaweed extract			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	18.29 c	25.03 ab	26.37 ab	23.23 c	25.47 a
	1	24.27 ab	25.63 ab	24.84 ab	24.92 bc	
	2	28.56 ab	25.56 ab	30.67 a	28.26 ab	
Solo F1	0	23.29 bc	27.07 ab	27.56 ab	25.97 a-c	27.02 a
	1	24.80 ab	29.01 ab	25.37 ab	26.39 a-c	
	2	29.27 ab	27.53 ab	29.29 ab	28.70 a	
Seaweed		24.74 b	26.64 ab	27.35 a	Humic acid	
Cultivar × Seaweed	Bellona F1	23.70 b	25.41 ab	27.29 a		
	Solo F1	25.79 ab	27.87 a	27.40 a		
Humic × Seaweed	0	20.79 c	26.05 ab	26.96 ab	24.60 b	
	1	24.54 bc	27.32 ab	25.10 b	25.65 b	
	2	28.91 ab	26.54 ab	29.98 a	28.48 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

The combined effect of humic acid and cultivar produced a significant enhance in yield (kg.m^2). Plants from Solo F1 cultivar that treated with humic acid at concentration of 2 ml/L had the biggest value (28.70 kg). no significant differences were noticed between the two cultivars in case of binary interaction (seaweed × cultivar). However, the peak yield estimated for Solo F1 plants applied with seaweed extract at level of (27.87 kg). The two bio stimulants significantly increased yield (kg.m^2) with the best yield (29.98 kg) belonged to plants taken a dosage of both bio stimulants 2 ml/L humic and 4 ml/L seaweed extract.

According to the complex interaction between the three factors, there was a significant amelioration in yield (kg.m^2). The Bellona F1 cultivar that treated with humic acid at concentration of 2 ml/L plus the seaweed extract (Seaforce1) with concentration of 4 ml/L was superior to Solo F1 cultivar in having the maximum yield (30.67 kg) as shown in Table 4.12 and Figure 4.12.

4.3.5. Yield (kg/plant)

The earned results in Table 4.13 appeared that the Solo F1 cultivar was not significantly different from the Bellona F1 cultivar in term of yield (kg/plant). The effect of humic acid was distinguished from the cultivar effect and application of 2 ml/L of humic acid led to a significant increase (5.98 kg) in yield (kg/plant) as compared to other treatments. The same influence was obvious according to the application of the seaweed extract (Seaforce1). Plants that sprayed with seaweed extract at concentration of 4 ml/L gave the highest yield/plant (5.74 kg).

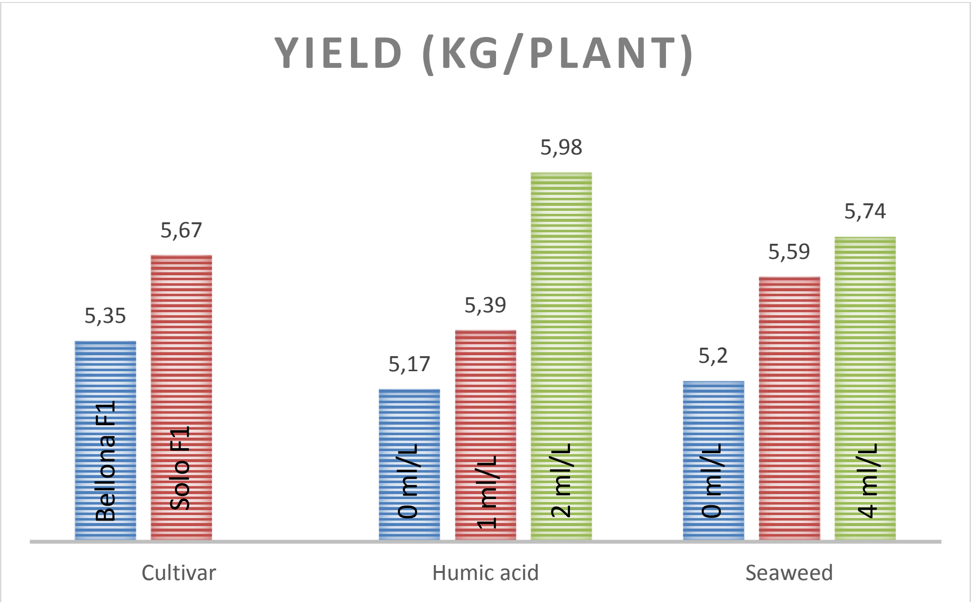

Figure 4.13. The effect of HA and SWE on yield (kg/plant)

The dual interaction (cultivar × humic acid) with supremacy for the plants of Bellona F1 cultivar treated with humic acid at level of 2 ml/L that owned the maximum yield/plant (6.03 kg). The yield per plant was not significantly influenced by (cultivar × seaweed extract) interaction. No significant variations were observed between the two cultivars respective to the above interaction. The same thing was not true in case of binary interaction between the two bio stimulants (seaweed × humic acid). The maximum yield per plant (6.30 kg) was measured for plants applied with humic acid at concentration of 2 ml/L and the seaweed extract (Seaforce1) at concentration of 4 ml/L in comparison with other treatments.

The combined effect of the factors resulted in a significant promotion in yield per plant and that was found in plant from Solo F1 cultivar dosed with humic acid at concentration of 2 ml/L along with the seaweed extract at concentration of 4 ml/L which possessed the highest yield per plant (6.44 kg) as demonstrated in Table 4.13 and Figure 4.13.

Table 4.13. Effect of HA, SWE and their interactions on yield (kg/plant) of two cucumber cultivars*

Cultivar	Humic acid	Seaweed extract			Cultivar × Humic	Cultivar
		0	2	4		
Bellona	0	3.84 c	5.26 ab	5.54 ab	4.88 c	5.35 a
	1	5.10 ab	5.38 ab	5.22 ab	5.23 bc	
	2	6.00 ab	5.37 ab	6.44 a	5.93 ab	
Solo F1	0	4.89 bc	5.69 ab	5.79 ab	5.45 a-c	5.67 a
	1	5.21 ab	6.09 ab	5.33 ab	5.54 a-c	
	2	6.15 ab	5.78 ab	6.15 ab	6.03 a	
Seaweed		5.20 b	5.59 ab	5.74 a	Humic acid	
Cultivar × Seaweed	Bellona F1	4.98 b	5.34 ab	5.73 a		
	Solo F1	5.42 ab	5.85 a	5.75 a		
Humic × Seaweed	0	4.37 c	5.47 ab	5.66 ab	5.17 b	
	1	5.15 bc	5.74 ab	5.27 b	5.39 b	
	2	6.07 ab	5.57 ab	6.30 a	5.98 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan’s multiple ranges test at 5% level.

4.4. Yield Qualitative Characters

4.4.1. Fruit Length (cm)

The experiment data showed significant differences between the two cucumber cultivar relating to fruit length with propensity for the Solo F1cultivar (13.19 cm). Fruit length was also improved by application of humic acid and the measurement of the greatest fruit length (13.24 cm) was recorded for plants treated with humic acid at level of 2 ml/L when compared with 0 ml/L level. Similar effect has been found in case of application of seaweed extract. Application of Seaforce1 with dosage of 4 ml/L gave the maximum fruit length which was estimated to be (13.28 cm) as outlined in Table 4.14.

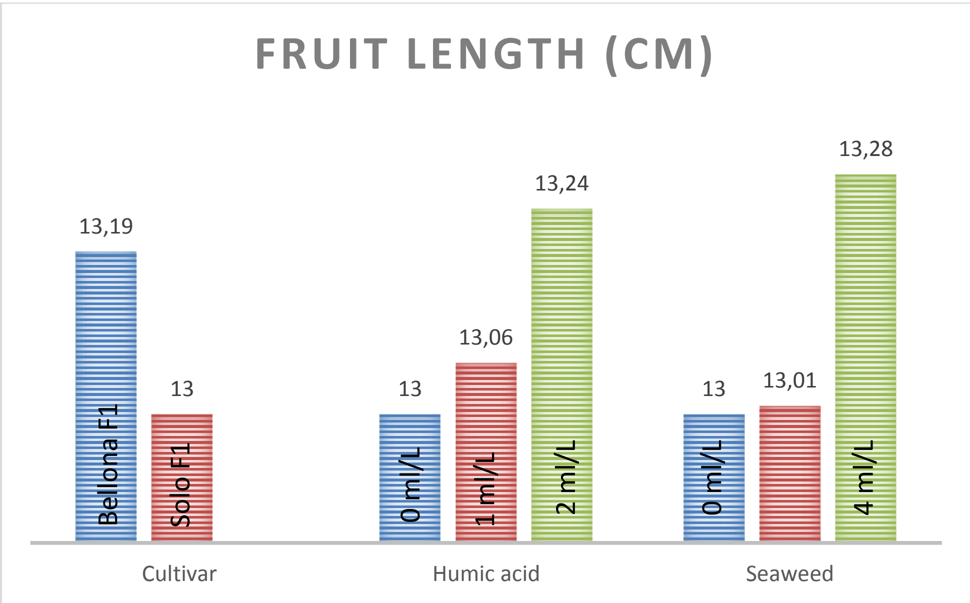

Figure 4.14. The effect of HA and SWE on fruit length (cm)

The results also demonstrated that the (cultivar × humic acid) interaction had a significant influence on fruit length character and Solo F1 plants received humic acid at concentration of 2 ml/L carried the tallest fruits with length of (13.41cm). The other binary interaction (cultivar × seaweed extract) resembled the previous interaction in enhancing fruit length and plants of Solo F1 cultivar treated with a 4 ml/L of Seaforce1 possessed better fruit length (13.46 cm) than Bellona F1 cultivar and other treatments. The effect of humic acid and seaweed extract caused a significant increase in fruit length accounting the highest value (13.53 cm) for plants applied with level of 2 ml/L of humic acid and level of 4 ml/L of the seaweed extract.

Table 4.14. Effect of HA, SWE and their interactions on fruit length (cm) of two cucumber cultivars*

Cultivar	Humic acid	Seaweed extract			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	12.40 g	12.97 c-f	13.52 ab	12.96 b	13.19 a
	1	13.23 bc	13.20 b-d	13.14 b-e	13.19 ab	
	2	13.40 a-c	13.11 b-f	13.73 a	13.41 a	
Solo F1	0	12.64 fg	13.17 b-e	13.28 a-c	13.03 b	13.00 b
	1	13.22 bc	12.89 c-g	12.66 e-g	12.92 b	
	2	13.13 b-f	12.70 d-g	13.34 a-c	13.06 b	
Seaweed		13.00 b	13.01 b	13.28 a	Humic acid	
Cultivar × Seaweed	Bellona F1	13.01 b	13.09 b	13.46 a		
	Solo F1	13.00 b	12.92 b	13.10 b		
Humic × Seaweed	0	12.52 e	13.07 b-d	13.40 ab	13.00 b	
	1	13.22 a-d	13.04 cd	12.90 d	13.06 ab	
	2	13.27 a-c	12.90 d	13.53 a	13.24 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

Respected to all factors interaction, there has been a significant impact on fruit length and the maximum fruit length (13.73 cm) was belonged to Solo F1 plants that delivered humic acid at 2 ml/L and Seaforce1 at 4 ml/L as shown in Table 4.14 and Figure 4.14.

4.4.2. Fruit Diameter (cm)

The obtained data in Table 4.15 revealed no significant differences between Solo F1 and Bellona F1 cultivars in fruit diameter. On contrary, significant variations in fruit diameter have been documented in case of humic acid application. The best diameter (2.27 cm) was estimated for plants treated with level of 2 ml/L of humic acid. Fruit diameter was also ameliorated by seaweed extract factor and plants received Seaforce1 at 4 ml/L surpassed plants received other treatments in having the highest fruit diameter (2.29 cm).

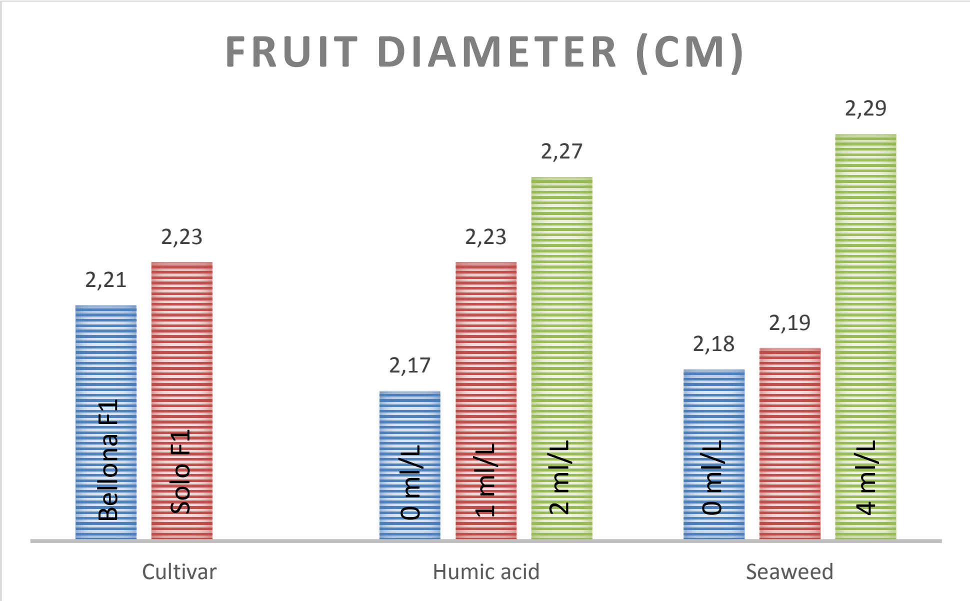

Figure 4.15. The effect of HA and SWE on fruit diameter (cm)

The influence of dual interaction between cultivar and humic acid was not significant regarding fruit diameter; however, the Solo F1 cultivar was somewhat better than Bellona F1 cultivar. The (cultivar × seaweed extract) interaction resulted in significant increase in fruit diameter with calculation of the greatest fruit diameter (2.30 cm) for Bellona F1 plants sprayed with 4 ml/L of Seaforce1. Concerning the (humic acid × seaweed extract) interaction, the maximum fruit diameter was measured for plants treated with 4 ml/L of humates and 4 ml/L of Seaforce1 (2.30 cm).

The same influence of triple interaction (cultivar × humic acid × seaweed extract) on fruit diameter have been recorded. Application of humic acid at level of (0 ml/L) and Seaforce1 at 4 ml/L on Plants from Bellona F1 cultivar produced the highest fruit diameter (2.38 cm) as compared to other treatments. This means that the humic acid did not take an important role in fruit diameter improvement in regard to the triple interaction and the dual interaction (humic acid × seaweed extract) as cleared in Table 4.15 and Figure 4.15.

Table 4.15. Effect of HA, SWE and their interactions on fruit diameter (cm) of two cucumber cultivars*

Cultivar	Humic acid	Seaweed extract			Cultivar × Humic	Cultivar
		0	2	4		
Bellona	0	1.99 e	2.14 c-e	2.23 a-d	2.12 b	2.21 a
	1	2.23 a-d	2.22 a-d	2.32 a-c	2.26 a	
	2	2.35 ab	2.18 b-e	2.27 a-d	2.27 a	
Solo F1	0	2.10 de	2.17 b-e	2.38 a	2.22 ab	2.23 a
	1	2.17 b-e	2.18 b-e	2.24 a-d	2.20 ab	
	2	2.26 a-d	2.26 a-d	2.30 a-c	2.27 a	
Seaweed		2.18 c	2.19 b	2.29 a	Humic acid	
Cultivar × Seaweed	Bellona	2.19 b	2.18 b	2.27 ab		
	Solo F1	2.18 b	2.20 b	2.30 a		
Humic × Seaweed	0	2.04 c	2.16 bc	2.30 a	2.17 b	
	1	2.20 ab	2.20 ab	2.28 ab	2.23 ab	
	2	2.31 a	2.22 ab	2.28 ab	2.27 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

4.4.3. Total Soluble Solid Percentage (TSS)

The field trial results indicated that the effect of cultivar factor was significant on percentage of total soluble solids and the Bellona F1 cultivar had better total soluble solids (5.65%) thant the Solo F1 cultivar. The other factor (humic acid) resulted in enhanced total soluble solids and the greatest soluble solids were estimated in fruits of plants applied with humic acid as concentration of 2 ml/L when compared to other treatments (5.76%). The same significant effect on soluble solids was favored to the foliar spray of Seaforce1 and the premium soluble solids (5.71%) was measured for plants given a 4 ml/L level of the extract (Table 4.16).

The effect of cultivar along with the humic acid significantly ameliorated total soluble solids with the supremacy for Bellona F1 cultivar plants had a dosage of 2 ml/L of humates that contained the highest soluble solids percentage (5.82%). In case of (cultivar × seaweed extract) interaction, the superiority was for plants from Solo F1 plants treated with 4 ml/L of Seaforce1 owning the best percentage of total soluble solids (5.82%).

The (SWE×HA) also significantly improved total soluble solids accounting the peak value (5.98%) for plants provided with solutions of 2 ml/L (HA) and 4 ml/L (SWE).

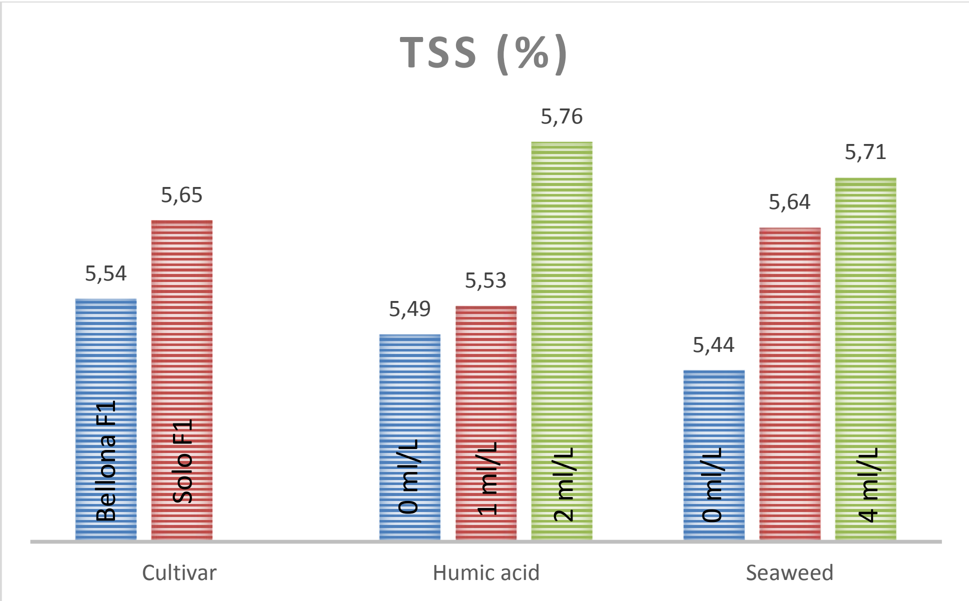

Figure 4.16. The effect of HA and SWE on total soluble solid (%)

Table 4.16. Effect of HA, SWE and their interactions on total soluble solids (%) of two cucumber cultivars*

Cultivar	Humic acid	Seaweed extract			Cultivar × Humic	Cultivar
		0	2	4		
Bellona F1	0	5.23 i	5.57 f	5.74 c	5.51 d	5.54 b
	1	5.25 i	5.27 hi	5.66 de	5.39 f	
	2	5.45 g	5.62 ef	6.05 a	5.71 b	
Solo F1	0	5.32 h	5.65 de	5.45 g	5.47 e	5.65 a
	1	5.69 cd	5.85 b	5.44 g	5.66 c	
	2	5.70 cd	5.85 b	5.91 b	5.82 a	
Seaweed		5.44 c	5.64 b	5.71 a	Humic acid	
Cultivar × Seaweed	Bellona F1	5.31 e	5.49 d	5.82 a		
	Solo F1	5.57 c	5.78 b	5.60 c		
Humic × Seaweed	0	5.27 g	5.61 c	5.60 cd	5.49 c	
	1	5.47 f	5.56 de	5.55 e	5.53 b	
	2	5.58 c-e	5.74 b	5.98 a	5.76 a	

*The same letters in means of each interaction was not significantly different from each other according to Duncan's multiple ranges test at 5% level.

The complex interaction between the three factors (cultivar, humic acid and seaweed) resulted in significant increase in percentage of total soluble solids and plants of the Solo F1 cultivar that supplied with humic acid at 2 ml/L and Seaforce1 at 4 ml/L had the maximum total soluble solids (6.05%) in comparison with Bellona F1 cultivar and other treatments as illustrated in Table 4.16 and Figure 4.16.

5. DISCUSSION

5.1. Effect of Humic acid and Seaweed Extracts on Vegetative Growth of Cucumber

It is obvious from the results (Tables 4.1, 4.2, 4.3, and 4.4) that application of humic acid and seaweed extracts significantly increased most vegetative growth characters (plant length, number of leaves per plant, plant dry weight, leaf area and chlorophyll percentage in leaves). The improved vegetative growth components could be due to the positive influences of the humic acid because of its capability to stimulate biological processes in plant such as photosynthesis and respiration and its role in enhancing cell membrane permeability. The beneficial effect of humic acid on vegetative growth parameters could attribute to the role of humates in improving and increasing nutrient uptake from soil and motivating root cell growth (Cacco and DellAgnolla, 1984; Russo and Berlyn, 1990 and Fahramand *et al*., 2012).

The improved growth characters of cucumber may return to the role of humic acid in enhancing plant growth because of its content of hormone-like substances that increase the plant growth and the nutrient uptake, possess an anti-stress activity against abiotic stress conditions like extreme temperature, pH, and salinity by decreasing the negative impact of any external stress (El-Hefny, 2010). Humic acid is considered as a major component of the soil organic matter and soil fertility since; they are functional in controlling chemical and biological properties of the rhizosphere (Nardi *et al*., 2005; Trevisan *et al*., 2009). Yasir *et al.* (2016) showed that the organic humic plus along with other organic fertilizers significantly enhanced nutrient uptake from soil and this positively impacted growth and yield parameters of cucumber crop.

Humic acid can increase plant growth and can stimulate soil microbes' activity like bacteria, fungi and supplies carbon as a source of it. Furthermore, it's a good chelate substance that suppresses some nutrients element leaching, losing and do provide many nutrient in soil such as calcium, phosphorus and micronutrient and it is capable controlling soil pH against changes caused from addition of mineral fertilizer (Leonard, 2008). Sayyedbagheri (2010) showed that humic substances directly and indirectly influence the production of protein, hormone–like activity, promoting photosynthesis, changes in enzymes" activity, absorption of macro and micro nutrients, suppress of toxic element, and enhancement of microbial population of soil. Kazemi (2013) indicated that the foliar spray of humic acid on cucumber plant made a significant enhancement in vegetative growth components in term of the dry weight of plant and its content of nutrient elements of N and K which positively affected and increased average of plant yield. Yousif (2011) revealed that there was a significant improvement in the percentage of chlorophyll, dry weight of plant as well as the total yield and the sum per plan when cucumber plant received foliar application of humic acid or through soil.

The increase in plant length, plant dry weight, number of leaves per plant and chlorophyll percentage may attribute to the role of humic acid in improved physical, chemical and biological properties of soil. Humic acid increase water holding capacity and assists in the correction plant choloresis and hasten cell division as well as improve protein synthesis and root development (Khaled and Fawy, 2011). Yaser *et al*. (2016) found in a field experiment that the application of humic acid significantly increased vegetative growth parameters of cucumber and that was apparent in chlorophyll percentage, plant dry matter and nitrogen percentage. Shafeek *et al*. (2016) revealed after conduction of a fieldtrial that application of humic acid either foliar sprayed or drenched to the soil significantly improved vegetative growth characters (plant length, leave number per plant and leaf area and protein percentage of cucumber crop.

The improvement in total chlorophyll percentage may be reasoned to the influence of seaweed extracts bio stimulants on chlorophyll decrease since they contain betain and betain-like compounds which function as chlorophyll enhancers. Thirumaran *et al*. (2009) studied the effect of seaweed liquid fertilizer on growth and yield of cucumber crop and showed that the seaweed fertilizer significantly enhanced vegetative growth and pigment content of plant as compared with control. Muhammad (2009) has demonstrated in a field study that applying the seaweed extract seaforce1 along of N fertilizer significantly improved stem length, dry weight and chlorophyll content of cucumber plant. Rouphael *et al.* (2017) indicated that the seaweed extracts predominately enhanced plant vegetative components, especially chlorophyll content of leaves and shoot biomass of cucumber plants.

The vegetative growth character increment may return to the positive effect of seaweed extracts application as these extracts are well-known to contain a desirable amount of macro and micro nutrients and numerous growth stimulant substances such auxins, cytokinins and gibberellins and vitamins. Auxins play a major role in promotion of root system development and cell division and enlargement resulting in better shoot growth; leaf area, plant length and plant dry weight. When sprayed on plants, seaweed extracts increase root growth and its capability of absorption of nutrients for soil and improve stem thickness and vegetative growth of plant. These extracts also improve water holding capacity through motivating the growth of beneficial soil microorganisms (Moore 2004; Gollan and Wright, 2006; Khan *et al*., 2009). Nour *et al.* (2010) showed that foliar spray of seaweed extracts resulted in significant increase in plant vegetative growth characters particularly plant height, number of shoots per plant and total dry matter. Shalaby (2012) conducted a field trial on the seaweed extracts effect on growth and yield of cucumber and clarified that the seaweed extract caused a significant amelioration of vegetative growth and yield characters of the crop.

The increased plant length of cucumber could be resulted from increased soil organic matter and improved nutrient uptake by humic acid application along with the apical meristem promoting hormone auxin, vitamins, amino acids and macro and micronutrients content of seaweed extracts which motivate the internode elongation plant growth upward (Khan *et al*. 2009; Craigie 2011; Yasir *et al.*,2016). Furthermore, the improved vegetative growth of cucumber plant could attribute to the combined influence of previously mentioned substances contained in the humic acid and seaweed extracts and their role in boosting plant health and plant ability to tolerate extreme environmental stresses like cold, heat, wind, drought and diseases with increasing the overall nutrition (Prakash *et al.*, 2018). Sarhan (2011) found that the application of seaweed extracts and humic acid resulted in improved vegetative growth and yield of potato crop.

No significant differences were seen between the two cucumber cultivars (Solo F1 and Bellona F1) in most vegetative traits except for plant length trait which was higher in Bellona F1 cultivar than in Solo F1 cultivar. This may attribute to the genotype of cucumber cultivars. Cucumber cultivar genotype expresses significant differences regarding vegetative growth traits (Patil and Patil, 1985).

5.2. Effect of Humic acid and Seaweed Extracts on Mineral Content of Cucumber

Tables 4.5, 4.6 and 4.7 illustrated that the application of humic acid and the seaweed extract (Seaforce1) significantly ameliorated mineral content (N, P and K) of cucumber leaves. The positive effect of humic acid on mineral content of leaves maybe due to the induction in the nutrient uptake from the soil. Humic acid can enhance the soil fertility through improving soil physical, chemical and biological properties of soil and enhance root growth and development leading to increment in nutrient element uptake by plants. Furthermore, humic acid is considered as a main source of organic matter and is a readily available source for carbon and nitrogen (Tenshia and Singaram, 2016). El-Shabrawy *et al*. (2010) showed in a field trial that the application of humic acid resulted in a significant increase in the mineral content (N, P and K) in the leaves of cucumber crop and they attributed this improvement to the positive action of humates in root growth stimulation and better nutrient uptake.

The increase in P element could attribute to the slow and continuous dissolution of phosphate minerals in the soil as a result of humic acid action in inducing phosphatase activity ((Pal and Sengupta, 1985). Ekinci *et al*. 2015 reported a significant increase in micro and macronutrients of cucumber leaves. The enhance in K element of leaves by humic acid application might be due to the role of humic acid in stimulating the biomembrane permeability for electrolytes which could be responsible for increased uptake of potassium K by plant roots (Samson and Visser, 1989).

The field obtained data also revealed that the use of seaweed extract as bio stimulant produced a significant improvement in mineral content of leaves. This could be since these extracts contain important plant hormones that affect root growth and development and thereby increase nutrient uptake and the best example is auxin hormone. Endogenous auxin is well-known to enhance root growth and development (Selvakumari and Venkatesan, 2017). On the other hand, the seaweed extracts contain considerable amounts of macro and micronutrients necessary for plant growth and development. El Sagan (2015) found out that the algae extracts used as foliar sprays at a concentration of (1.5 mg/L) was responsible of significant increments in cucumber plant growth as well as chemical content (N, P and K) of leaves.

The increase in (K) content of leaves might be attributed to the presence of potassium element as a main content of these extracts (Shehata *et al*., 2011). Ali *et al*. 2015 indicated in a field trial that the application of seaweed extracts has resulted in maximum content of macronutrients (N, P, K and Ca) in leaves of tomato crop.

5.3. Effect of Humic acid and Seaweed Extracts on Quantitative yield characters of Cucumber

The field trial obtained data appeared a significant influence of humic acid and the seaweed extract Seaforce1on all quantitative yield characters of cucumber (number of fruit per plant, single dry weight of fruit, early yield and total yield). The single weight of fruit character was exceptional in case of humates effect which was non-significant on it. The increase in quantitative yield components may attribute to the unique content of organic matter in humic acid that provide numerous macro and micronutrients for plant and its action in improving soil physical, chemical and biological properties through increasing water holding capacity, protecting the mineral from leaching, stimulating root system development, adjusting the soil PH, increasing the activity of beneficial microorganisms in the soil and enhancing nutrient elements uptake by plant roots (Nardi *et al*., 2005; Trevisan *et al*., 2009; El-Hefny, 2010).

The goodness in quantitative yield characters of cucumber crop might also attribute to the impact of hormone-like substances contained in humic acid especially gibberellins along with mineral nutrients that increase the plant growth, productivity and the nutrient uptake. Furthermore, the humic acid has an anti-stress activity against abiotic stressful conditions such as extreme temperature, pH, and salinity and can suppress the negative effect of any external stress (El-Hefny, 2010). Salama (2009) revealed that soil applications of humate caused apparent alleviation of the negative effects of salinity on tomato plants. Meena *et al*. (2014) investigated the influence of humic acid on growth and yield of cucumber plant and the experiment results showed that the humic acid was supreme in improving and enhancing the yield traits like number of fruits per vine, fruit weight (g), fruit length (cm), fruit diameter (cm), volume of fruit (cc), yield per plant (kg) and yield per square meter (kg). Shafeek *et al*., 2014 reported a significant increase in the total yield and yield quality of hot pepper through application of humic acid and biofertilizers.

The beneficial impact of humic acid on the flowering of cucumber could be another reason for ameliorated yield characters. Humic acid act like a hormone and decrease number of days elapsed from transplanting to flowering. And this was found and reported by Alkharpotly *et al.* (2017) in a field trial that was carried out by them to study the effect of humic acid and seaweed extracts on the growth and yield of strawberry plants. Their data indicated that plants treated with humic acid possessed the least number of days from transplanting to flowering in comparison with untreated plants. Feleafel and Mirdad (2014) who recorded amelioration in flowering of tomato plants as a result of enhanced humic acid level leading to an earlier flowering and an increase in the number of flowers per cluster.

The positive influence of the humic acid on yield potential of plants could be due to its premium impact on the vegetative growth since it is provide more photosynthetic substances required by plant for fruit formation and development and harry ups their transportation to storage plants (Salib, 2002). Sure *et al*. (2012) studied the effect of tow biofertilizers (humic acid and nitroxin) on the growth and yield of cucumber and showed that the biofertilizers produced a significant increase in growth and yield attributes of plant in term of fruit diameter, length and fruit yield ha^{-1}. Mohamed-Fahmy (2012) measured the highest fruit weight and fruit yield per plant for cucumber and water melon plants applied with humic acid when compared to control plants.

On the other hand, seaweed extracts can have a beneficial impact on yield characters of cucumber. This advantage of seaweed extracts could be as of humic acid on early flowering and extensive flowering of the plant due to its content of the hormone cytokinin which stimulates floral initiation which improve yield quantity and quality. This is evident in transgenic Arabidopsis plants which are deficient in cytokinins. They usually flower later than normal but when applied with high levels of cytokinin they start to flower earlier than normal (Bernier and Perilleux, 2005). Alkharpotly *et al*. (2017) reported a decrease in number of days from flowering to transplanting (early flowering) and an increase in number of flower cluster with increasing seaweed extract level in strawberry plants which positively reflected on yield.

Foliar application of seaweed extracts might produce an enhance in plant growth and yield they contain high levels of plant growth hormones such as auxin, gibberellin and cytokinin as well as other elements like macro and micro nutrients which ameliorate the moisture holding capacity of soil, make nutrients in available form for plants, improve root system growth and accelerate the vitality of soil microorganisms and increase plant tolerance to extreme stress conditions (Moore 2004; Gollan and Wright, 2006; Khan *et al.*, 2009). Suhail (2013) recorded a significant enhance in yield traits of cucumber in terms of number of fruits, yield per plant and total yield when treated with seaweed extract and mycorrhizal fungi. El Sagan (2015) reported a significant improvement fruit weight, number of fruit/plant, yield and chemical content of cucumber plants when sprayed with seaweeds, yeast extract and compost tea extract.

The yield characters were significantly higher in plant received seaweed extracts and humic acid. This could be due to double beneficial effect of both of them. Seaweed extracts and humic acid are known to contain natural growth regulators, vitamins and a wide range of nutrient elements that positively affect plant growth and yield. Our findings are consistent with the findings (Sarhan 2011) and Alkharpotly *et al*. (2017) who reported the same good influence of interaction between seaweed extracts and humic acid on the yield traits of plant.

Significant differences were observed between the two cultivars concerning fruit weight and early yield but not total yield and fruit number per plant. These differences could attribute to cultivar genotype. Yield is well known as a complicated phenomenon controlled by many genes and expression of such genes is continuous in nature (Hanchinamani, 2006).

5.4. Effect of Humic acid and Seaweed Extracts on Qualitative yield characters of Cucumber

Data in Table 4.12, 4.13 and 4.14 showed a significant increase in the yield quality of cucumber crop. The premium performance of cucumber respective to yield qualitative characters might attribute to its high content of organic matter that provides numerous macro and micronutrients for plant growth and development. Humic material is synthesized through decomposition of organic material and used as soil fertile substance in requirement for improving soil structure and soil microbial activity. Humic acid produce consists of O (42- 46%), C (44-58%), N (0.5-4%) and H (6-8%) in addition to frequently other elements. Moreover, it makes the soil more fecund and ameliorates the availability of nutrient elements through the supremacy it possesses on mineral superficies. Spraying doses of these humic substances also rise plant growth, and enhance total yield and fruits quality in a number of plant types (Larcher, 2003; Yildirim, 2007).

Shehata et al. 2012 reported that cucumber plants treated with (1.5 ml/L) of humic acid had the tallest fruits as compared to untreated plants. Shafeek et al. (2016) carried out an experiment investigating the effect of foliar and soil drench application of humic acid on growth, fruit output and fruit nutritional value of cucumber crops and they concluded that the humic acid significantly enhanced yield quality represented in fruit tallness and wide, N, protein and TSS content. Meena et al. (2014) found in another field trial that the application of humic acid resulted in improved growth and yield characters such as number of fruits per vine, fruit weight (g), fruit length (cm), fruit diameter (cm), volume of fruit (cc).

Another reason for increased fruit goodness of cucumber may be because of the effect of humic acid on plant growth and development. Humic substances humic and fulvic acid) own a positive effect in increasing cell membrane permeability, respiration and photosynthesis and production of carbohydrates in plant which directly influence the fruit quality traits. Likewise, humic acid improves soil water holding capacity and lessens the leaching of nutrient elements from the soil and increase the activity of beneficial microorganisms in the soil (Nardi *et al.*, 2005; El-Hassan *et al.*, 2009; El-Hefny, 2010; Fahramand *et al.*, 2014). El-Hassan and Husein (2016) showed that foliar application of humic acid possessed a significant influence on tomato plants and elevated growth and yield quality in term of fruit firmness, total soluble solid percentage and decreased total titraTable acidity in comparing with control.

The increase in fruit quality traits could be reflected from the influence of humic acid on the protein and carbohydrate production by plants. It is common that the humate substances can increase photosynthesis rate and hence the synthesis of carbohydrates is enhanced leading to improve the nutritional quality of fruits. This has been proved by Prakash *et al.* (2018) that showed in a field trial that the application of humic acid with the level of (0.4%) resulted in better carbohydrate and protein content in okra plant. The humates substances can also improve the potassium and calcium content in plant and thereby enhance the fruit goodness. Sahin *et al*. (2014) studied the influence of humic acid on growth and yield of tomato crop and concluded that the humic application was pioneer in ameliorating the potassium (K) and calcium (Ca) content of plant when compared with non-treated plants.

Results (in Tables 4.12, 4.13 and 4.14) unveiled a significant impact of seaweed extract (Seaforce1) on yield quality of cucumber crop. The increase in the percentage of total soluble solids could attribute to the positive effect of seaweed extracts on leaf area and efficiency of photosynthesis process (Jensen, 2004). Rouphael *et al*. (2017) investigated the influence of seaweed extract on plant and found that the seaweed extract was effective in enhancement of fruit quality components that was evident in fruit dry matter and total soluble solids content. Haidar *et al*., (2012) investigated the effect of seaweed extracts on growth and yield of potato crop and recorded an increase in plant yield and its quality in term of nitrogen percentage, total soluble solid percentage and protein percentage.

The improvement in fruit quality might be because of plant growth regulators presented in seaweed extracts such auxins, cytokinins, and gibberellins that control growth and structural development of the plant (Selvakumari and Venkatesan, 2017). Moreover, theses extracts are also known to contain considerable amounts of macro and micronutrients like Fe, Zn and Mn in compost and K, Ca, Mg, S and Fe. These elements are required for vegetative growth, chlorophyll synthesis and photosynthesis rate which enhance flowering and fruiting of plants (Blunden and Liu, 1996). Ahmad and Shalaby (2012) studied the effect of seaweed extracts on cucumber growth and yield of cucumber and indicated a significant enhance in fruit quality of crop as a result of application of seaweed extracts.

Cultivars were significant from each other in term of total soluble solids and fruit length. This may refer to the genetic characteristics of the cultivars. Soleimani *et al*. (2009) reported a significant difference in fruit quality between 15 varieties of cucumber crop.

6. CONCLUSION AND RECOMMENDATIONS

6.1. Conclusion

It can be concluded from the results of the current experiment that;

1. Foliar application of humic acid and the seaweed extract (Seaforce1) and their interaction improved vegetative growth and yield and its quality of cucumber crop.

2. The cultivar factor significantly affected some vegetative and yield parameters, whereas other characters were not influenced

3. The interaction between humic acid and seaweed extract significantly increased vegetative, quantitative and qualitative yield characters of cucumber.

4. Interaction between cultivar and the two bio-stimulants caused a significant increment in most vegetative growth and yield parameters of cucumber crop.

5. The effect of the three factors (humic acid, seaweed extract and cultivar) was significant on cucumber growth and yield and its quality

6. Significant differences were observed between the two cucumber cultivars for vegetative parameters as well as yield (quantitative and qualitative) of cucumber crop.

7. The humic acid and seaweed extracts as liquid biofertilizers and bio stimulants together can be used as a substitute for chemical fertilizers that harm the human and animal health and deteriorate our environment.

6.2. Recommendations

According to the previous conclusion the following ideas can be recommended;

1. Cucumber crop is very responsive to the application of HA and SWE, it is heavily recommended that these two biostimulants should be used in cucumber production.

2. More scientific studies should be carried out in our region to investigate more about the beneficial contents of these natural substances and a combination of these extracts should be applied in vegetable production scope to move toward more sustainable agriculture in our country.

3. Bellona F1 cultivar is mostly recommended for cucumber greenhouse production.

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