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Investigation of the Effect of Foliar Application of Seaweed Extract as growth bio-stimulants (Ascophyllum nodosum) on Quantitative and Qualitative Characteristics of Three Tomato Cultivars (Solanum Lycopersicon Mill)

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ABSTRACT

In order to study the effect of foliar application of seaweed extract as a bio-stimulant agent on some quantitative and qualitative traits of tomato, a factorial experiment was conducted in a randomized complete block design with four replications in 2014 and was implemented in the greenhouse mechanized Gol Azin Maghsoud company located in Toos Industrial Township of Mashhad. The treatments consisted of seaweed extract at four levels (distilled water) of 1.2 and 3 ml/L (seaweed extract with Stimplex brand) and cultivars in three levels: Hungarian Mobil, Mobil's Dutch and Super Queen. The results of the experiment showed that the concentration of 2 ml/L had a significant difference in the number of panicles, number of internodes, date of flowering and number of fruits per panicle. In this research, there were no significant differences in other studied traits, but there was a significant difference between the cultivars.

Keywords: *Tomato, Foliar application, Bio-stimulant, Cultivar .*

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1. INTRODUCTION

Tomato is a perennial herb of the family of Solanaceae and an important source of antioxidant compounds, lycopene, and polyphenols (Lai et al., 2007). This plant is one of the important fruits of vegetables growing in Iran that due to the presence of vitamins A, C, and various foods, its per capita consumption is increasing in Iran (Golchin and Aflaki, 2004). In recent decades, the consumption of chemical inputs in agricultural lands resulted in environmental problems, including water resources` pollution, reduced agricultural quality and reduced soil fertility (Sharma, 2002). Therefore, the emphasis of future agricultural systems is based on the reduction in energy consumption, inputs and proper management of water, soil, biological resources, and environmental preservation in order to achieve good and sustainable performance (Hajilo et al., 2010). The proposed farming problem is the excessive use of farmers from chemical fertilizer during the production process, especially for greenhouse products (Javanmardi and Azadi, 2012). In recent years, however, efforts have been made to introduce the agricultural community to produce organic or healthy products and the use of licensed inputs in production. One of the permitted inputs in organic production is the use of seaweed extract, which can be a viable alternative for the chemical fertilizers. While the use of seaweed as a food source for humans has been raised by the Japanese from 700 B.C., it was the first time in the 12th century that it was used by the British as an agricultural input. With the production of chemical fertilizers and pesticides, their consumption dwindled gradually until the 1950s and 1960s, that the interest in producing healthy and organic products caused the attention of everyone to interest the substance again. Today, the use of seaweed in countries such as Romania, the United Kingdom, France, Japan, and China are widely used for agricultural and garden production (Verkleij, 1992). For centuries, seaweed has been used as a fertilizer in coastal areas (Craigie, 2011). Research has shown that seaweed contains plant hormones, such as auxin, cytokinin, and abscisic acid (Lai et al., 2007). It is also observed that the growth of plants (Van Staden, Upfold and Drewes, 1994), degree of chlorophyll (Blunden, Jenkins and Liu, 1997), flowering and performance (Eris et al., 1995) increase. The study of the effect of the application of seaweed extract on plants has shown that the use of seaweed extract in seed germination, improved plant growth, increased the performance and plant strength against living and non-living tensions (Booth, 1965). It has been reported that these effects are due to the presence of substances that increase cell metabolism such as plant growth regulators including auxin, gibberellin, and cytokinin (Jameson, 1993) as well as organic osmolytes including betaine, amino acids, minerals and vitamins (Berlyn and Russo, 1990). According to the consequences of the indiscriminate use of chemical fertilizers and pesticides during the agricultural production process, this study was conducted to determine the optimum level of using seaweed extract as a nutritious organic substance and stimulated the increase of the quantity and quality of tomato fruit.

2. MATERIAL AND METHODS

In this experiment, the seaweed extract of *Ascophyllum nodosum* (brown algae) was used with Stimplex brand. Seaweed extracts are produced and marketed by various brands such as Stimplex, Phylgreen Vega, Marmarin, Dalgin, and Algaren. Stimplex is manufactured by a Canadian company. From a botanical point of view, *Ascophyllum nodosum* is a large, common cold water seaweed or brown alga and being the only species in the family, Fucaceae, only grows in the northern Atlantic Ocean and the north-western coast of Europe. In terms of formulation and appearance, it is the brown-colored liquid and is mixable with surfactants (moyans or wetting agents). *A. nodosum* contains growth promoters, organic macronutrients, and micronutrients, vitamins, antioxidants, organic acids, organic NPK (N, P, and K), amino acids, plant hormones derived from *Ascophyllum*. Stimplex has been successfully tested on 80 products from 70 countries and is currently being used. It is quite natural and organic and has no adverse effects on the environment and is registered by the United States` Environmental Protection Agency. The factorial experiment was conducted in a randomized complete block design with 3 × 4 array, which has two factors. The first factor was cultivar in three levels (Hungarian Mobil, Mobil's Dutch and Super Queen), and the second factor was the concentration at four levels (zero, 1, 2, and 3 ml/L). The site of the experiment is Gol Azin Maghsoud Company that is located in phase 1 of Toos Industrial Township of Mashhad, which is geographical, in the northwest greenhouse, it has longitude and latitude of 59.37 and 36.19 degrees, respectively and meters above sea level is 10.65 meters. First, in the method, the seeds were cultivated in a styrofoam tray containing coco peat and perlite with a ratio of 40:60. Feeding of seedlings was carried out as fertigation with recommended concentrations from the second week after seed germination (Javanmardi and Azadi, 2012). It should be noted that the seedlings were maintained to the greenhouse until the time of transfer to the mainland, and after transfer time (2015/05/01), the seedlings were transferred to plastic pots with the dimensions of 40 × 50 m^2, which lasted about 6 weeks from seed crop. At the transfer time, the trays were first irrigated, and then, in order to reduce wilt and the error rate, the transplantation was carried out early in the morning. The average temperature of the greenhouse during the day was 24-28 °C and at night was 18-22 °C, and the average relative humidity was 50-60% during the growth period, which was supplied by fogger and fan and pad system.

Method in greenhouse

The method of applying treatments was spraying (foliar application) with zero concentrations (distilled water) 1, 2 and 3 ml/L in five stages with a back sprayer. Due to the high surface tension of Stimplex, surfactant (wetting agents) was used at a concentration of 1 ml/L. The use of surfactant caused to decrease the surface tension of the solution, and therefore all the organs of the plant became completely wet and the solution was well absorbed. Also, the foliar application was performed early in the morning due to preventing soluble evaporation from the plant's organs and burning leaves. The foliar application was done in five steps at the intervals of 10 days as follows.

1. The first foliar application was carried out at a 20 cm growth stage (when the plant height reached 20 cm).
2. The next steps of the foliar application were carried out every 10 days until the last step.

In this experiment, the following traits were examined and measured.

Date of flowering: The flowering date was recorded with the advent of the first flower panicle per plant.

A number of panicle per plant: After the first stage of the foliar application, it was counted.

A number of flowers per panicle: Counting and recording with the advent of the first panicle.

Chlorophyll index (Spad number): In order to better see the effect of foliar application, ten days after the last step of the foliar application and ten times per plant was measured by chlorophyll meter (Japan's chlorophyll meter, model 502).

An average number of internodes, mean length of internode, the average length of main and subsidiary branch: They were measured at the end of the growth period.

Volume of fruit: Using a graduated cylinder, first, water was poured into a certain volume inside the cylinder, then the initial volume of water was written and after dropping the fruit into the volume cylinder, the water volume was recorded. By calculating the difference of initial and secondary volumes, the fruit size was measured in terms of cm^3.

The number of cracked fruits: Each harvesting step was counted separately and in the end, the total was recorded.

Percentage of fruit sunburn: Due to the fact that the experiment was done inside the greenhouse, and on the other hand, when the intensity of light was high (60 kilos lux), shading was done automatically, so the sunburn was not observed.

Finally, the results of all traits were statistically analyzed using JMP8 software, analysis of charts were performed by Excel software, and drawing and comparison of mean traits were performed based on LSD (least significant difference) test at 5% level.

Table 1. Mean square of measured traits

Start flowering	Number of internodes	Spad number	Fruit cracking (number of fruits per plant)	Number of panicles	Degrees of freedom	Sources Change
0.40^{ns}	0.25^{ns}	0.01^{ns}	0.02^{ns}	0.90^{ns}	3	Repeat

20.02**	23.91**	0.06ns	0.13ns	2.90**	3	Fertilizer
0.14ns	0.06ns	4.02**	5.68**	1.31ns	2	Cultivar
0.14ns	0.06ns	0.32ns	0.07ns	0.20ns	6	X cultivar fertilizer
0.28	0.18	0.17	0.14ns	69/0	33	Error

*, ** and ns indicates significance at the probability level of 1, 5, and not significant.

Table 2: Mean square of measured traits

Number of internodes per plant	Date of flowering	Number of fruits per panicle	Number of panicle per plant	Seaweed extract
40.16c	50.66a	2c	15.83b	Control
40.91b	49.91b	2.83b	16.16ab	1 ml/L
43.41a	47.66c	3.66a	17a	2 ml/L
41b	49.83b	2.66b	16.25ab	3 ml/L

Table 3: Comparison of the average of measured traits

The volume of fruit in terms of Cm^3	Sub-branch length	Main branch length	The length of the internodes	Number of fruits	Degrees of freedom	Sources Change
23.07ns	0.02ns	0.34ns	0.001ns	0.08ns	3	Repeat
31.63ns	0.02ns	0.34ns	0.001ns	5.63**	3	Fertilizer
228.81*	7.91**	10.56**	0.17**	0.39ns	2	Cultivar
31.59ns	0.01ns	0.24ns	0.001ns	0.11ns	6	X cultivar fertilizer
56.47	0.09	0.23	0.001	0.15	33	Error

*, ** and ns indicates significance at the probability level of 1, 5, and not significant.

In each column, averages with the same letters were not statistically significant in terms of the LSD test at 5% level.

Table 4. Comparison of the average of measured traits

Cracking fruits)	Spad (number of chlorophyll index	Fruit size	The average length of the sub-branch	The average length of the main branch	The average length of internodes	Cultivar
2b	124.08a	141.75a	36.88a	64.41a	4.63a	Hungarian Mobil
B2	123.46b	137.84ab	36.18b	63.48b	4.5b	Mobil's Dutch
3.06a	123.09c	134.18b	35.47c	62.79c	4.42c	Super Queen

In each column, averages with the same letters were not statistically significant in terms of the LSD test at 5% level.

3. RESULTS AND DISCUSSION

Results of the analysis of variance of data (Table 1 and 2) showed that the effect of foliar application of seaweed extract on number of flowers per panicle, average length of the main branch (plant height), average length of sub-branches, average length of internode, fruit size and number of sunburn fruit, cracking and chlorophyll index were not statistically significant, but there was a significant difference between the cultivars at about 1%. Seaweed extracts and cultivars did not have a significant difference in the number of flowers in the panicle. It was observed that in the concentrations (0, 1, 2 and 3 ml/L), the best result was related to the concentration of 2 ml/L, and the lowest was the control. The results of this study were inconsistent with previous studies on the positive effect of foliar application of seaweed extract on increasing the height of bean (Sivasankari et al., 2006) and tomato (34% increase compared to control at 5% concentration of seaweed extract) (Weisburger, 2002). While the date of flowering and the percentage of fruit formation was consistent with previous results (Khan et al., 2009). There was also no significant difference between cultivars and fertilizer (interaction between fertilizer and cultivar). It has already been reported that the use of seaweed extract increased flowering and fruit formation in many plants (Abetz and Young. 1983), especially greenhouse tomatoes (Crouch and VanStaden. 1992). It has also been reported that the seaweed extract contains compounds that increase root growth and vegetative growth and development of the vegetative stage and ultimately cause further flowering (Khan et al., 2009; Metting, Rayburn, and Reynaud, 1988). The role of cytokinins in the reproductive organs of the plant are as a food mover towards growing fruits (sinks) or, in other words, cytokinins act in the reproductive organs like a strong sink, and thus direct food to these organs (reproductive organs) (Adams-Phillips, Barry and Giovannoni. 2004); this movement towards the reproductive organs and flowers that are becoming fruit, ultimately leads to an increase in the power of attaching fruit tails to the plant, reducing the drop in flower and fruit, and ultimately increasing the percentage of fruit formation. According to the above, the use of seaweed extract through increased plant growth leads to accelerates flowering and even increases flowering and the percentage of flower formation into the fruit. Therefore, the results of this study on the increase in the number of flower to fruit conversion caused by seaweed extract were consistent with previous results (Zodape et al., 2011). It was also observed that the seaweed extract had no effect on the chlorophyll index and the results of this study were consistent with the previous results about the effect of seaweed extract on the chlorophyll index (Javanmardi and Azadi, 2012), but it contradicted the results of Blunden et al., (Blunden, Jenkins and Liu, 1997).

4. CONCLUSION

By examining the exact results, it can be concluded that increasing the number of panicles, the number of internodes, the number of fruits in the panicle and accelerating the onset of flowering at the concentration of 2 ml/L and the lack of influence of seaweed extract on the number of flowers in the panicle, the fruit size, percentage of cracking and average length of main branch and sub-branch, chlorophyll index, average length of internode in this concentration and contrary to the results of other researchers may be related to the algal botanical origin, location, time, and even differences in the used concentrations of seaweed. Therefore, according to the results of this study, it is recommended to use excellent fertilizers such as seaweed extract to prevent environmental degradation, reduce the cost of purchasing chemical fertilizers, ultimately increase the growth performance.

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