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REGULAR ARTICLE

# IMPROVING GROWTH AND PRODUCTIVITY OF TOMATO BY SOME BIOSTIMULANTS AND MICRONUTRIENTS WITH OR WITHOUT MULCHING

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## ABSTRACT

Two field experiments were conducted during 2014 and 2015 growing seasons to assess tomato growth and yield as affected by some biostimulants and micronutrients with or without mulching type. Certain physiological characters were also examined, plant height, the number of branches per plant chlorophyll a, nitrogen %, red fruit weight and total yield per plant as well as fruit firmness and ascorbic acid concentration in fruit was increased in tomatoes under black plastic mulch compared with bar soil. Application of either biostimulants or micronutrient used to increase all growth and yield characters as well as photosynthetic pigments, ions percentage, and fruit quality. Additive effects were shown under mulching, seaweed extract proved to be the most effective in this respect. It could be recommended that spraying tomato crop at 35 and 50 d from transplanting with 500 mg/l seaweed extract under clear or black plastic mulch in order for inducing the highest yield and improve fruit quality.

## INTRODUCTION

Tomato (*Solanum lycopersicum* L., family Solanaceae) is the foremost popular and widely grown vegetable worldwide, for its food and other industrial values [1]. According to FAOSTAT 2015, about 8,533,803 tons of tomato fruits were produced in Egypt. To increase tomato production, several investigations suggested using mulching and/or biostimulants as well as micronutrients [2-4]. Mulch preserves soil moisture, reduces production costs and it is highly effective in controlling weeds, various diseases and pests and reduced soil erosion, leaching of fertilizers [5, 6], and could account for improved yield [7]. Mulch is any material (organic or inorganic) placed on the soil surface to conserve moisture, maintain favorable soil temperatures around plant roots, that results in better plant growth and development [8].

Polyethylene is the foremost used plastic mulching in agriculture as it has numerous qualities when compared to other alternatives [4]. Djigma and Diemkouma [9] proved the benefits of using polyethylene mulch in eggplant and tomato. Organic mulch in specially, straw provide several qulaities like weed control [4, 10].

Using biostimulants for promoting plant growth and productivity has recently received increasing attention worldwide [3, 11]. Seaweed extracts (Swe; *Ascophyllum nodosum* Jol.) as organic biostimulants is fast becoming accepted practice in modern agriculture for sustainable production [12]. Swe contains phytohormones [3], certain micro-and macro-nutrients [14], and secondary metabolites [15]. Swe has been used as a foliar application to accelerate growth, yield, and quality, nutrient uptake, photosynthetic pigments, and resistance to stress factors of many crops [3, 11, 16].

Thiamine (Thi) could be considered as bio-regulators materials that in low concentration exerted a profound impact upon plant growth and development [17]. In this concern Abdel Aziz, Nahed *et al.* [18] showed an increase in pigments in *Thuja orientalis* L, plants under Thi treatments. Similarly, Farouk *et al.*, [19] indicate that application of thiamin increased tomato plant growth, photosynthetic pigments, NPK% and total fruit yield.

Micronutrients have been known to increase the yield and improve the quality of different crops [20, 21, 22]. Using soil organic matter provides most of the micronutrients [23]. Foliar application with differing micronutrients can overcome micronutrient deficiency in the subsoil [20]. Micronutrients play an important role in the physiological processes of many crops. They are required for plant activities like respiration, meristematic development, chlorophyll biosynthesis, photosynthesis, energy system, protein, oil synthesis, phenolic compounds additionally exogenous and applications of micronutrients have been reported in accelerating yield and quality in tomato [24]. Zinc is an important trace element for plants [25], photosynthetic pigment biosynthesis, pollen function and fertilization [26]. Iron and Zn have many essential roles in plant growth and development [27-29]. The present study aimed to evaluate the impact of two biostimulants (seaweed extract, thiamine) or micronutrients (Zn and Fe) with or without mulching type on growth, yield and some physiological characters of tomatoes.

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## MATERIALS AND METHODS

Two field experiments were conducted during the two successive early summer seasons of 2014 and 2015 at a private farm ($31^0$12'30,2 N $31^0$29'29,4 E) in Shirbin, Dakahlia Governorate, Egypt under drip irrigation system with or without mulching types (Bs, Cpm, Bpm, and Sm). In addition to distilled water as a control, tow biostimulants denoted (Swe and Thi), as well as (Zn and Fe) well evaluated.

### Field site

Before planting, random soil samples of the experimental site were collected (0-30 cm depth), air dried, grounded, mixed and kept in plastic bags for the analysis. The representative sample was subjected to mechanical and chemical analysis as described by [30]. The soil was loamy-clay (25.82 and 25.95% sand, 32.66 and 32.45% silt, 41.52 and 41.60% clay in both experimental season respectively), with normal level of organic matter (1.22 and 1.65% in both season) The soil pH (soil paste) was 7.82 and 7.62 and the electrical conductivity (1:5 soil extract) 1.12 and 1.16 ds $m^{-1}$ in both season respectively.

### Experimental design

A randomized complete block design in a factorial arrangement was adopted with three replications. The experimental unit area was 135 $m^2$including three ridges, each 30 meters long and 150 cm apart, and the distance between the hills were 30 cm apart. The study was performed using determinate fresh market tomato (*Solanum lycopersicum L.*) cv. Master RS that obtained from Agric. Res. Center (ARC), Ministry of Agric. Egypt.

### Planting procedure

The Tomato seedlings (4-5 mature leaves; 45 d) were planted in an open field on 1st March in both seasons, after placing the mulches types by hand. The plowed soil was fertilized with 20 percent of the nitrogen as ammonium nitrate (33.5%N), potassium as potassium sulfate (48% $k_2O$) and 50 percent of the phosphorus as calcium superphosphate (15.5% $P_2O_5$) from the recommended fertilizer requirements as recommended by ARCE. The remaining amount of nitrogen (urea 46.5%N+ammonium nitrate 33.5%N), potassium (48% $K_2O$) and phosphorus as phosphoric acid (85%$P_2O_5$) were applied through the drip tube throughout growth of plants with other soluble fertilizers such as calcium nitrate (15.5 %Ca), magnesium sulfate (50% $Mg_2O$). Plants were foliar sprayed at early morning with a sprayer (20 l in volume) to run-off, at 35 and 50 d from transplanting in each experimental seasons after adding tween 20 as a surfactant. The experiments included the treatments as follows 1-Control (tap water). 2-Seaweed extract (Swe) at 500 mg/l. 3-thiamin (Thi) at 100 mg/l. 4-Zinc chelated (Zn15% EDTA) at 100 mg/l 5-Iron chelated (Fe13% EDTA) at 500 mg/l under bare soil and or mulching types including clear plastic mulch"50-55 micron; Cpm", black plastic mulch"20-25 micron, Bpm", straw mulch "Sm at 5-7 cm thick".

The crop was irrigated day after day by a trickle irrigation system, consisting of one low-density polyethylene trickle line for each crop row (16 mm diameter) and emitters of 4 Lh-1 separated by 0.30 m. During the growing season, systematic tomato plant protection against fungal diseases was carried out. At 10-day intervals, the following plant protection sprays were applied: Rizolex-T and Ridomil Gold ® MZ Pepite 67.8 WG.

### Sampling dates and data collection

At 70 d from transplanting, a random sample of five plants was taken from each experimental unit to estimate the growth parameters, i.e. (plant height "cm", shoot fresh and dry weights "g"). In addition, like photosynthetic pigment concentration (mg/g FW), as well as ion "N, P and K" percentage in the shoot were also determined.

At harvesting (110 d from transplanting), the fruits were hand harvested and determined, red fruit weight, colored fruit weight and total yield per plant. A representative sample of 10 healthy fruits from each experimental plot for determination fruit quality, as follows: Total soluble solids (%); it determined by using Karl Zeiss hand refractometer according to [31]; Fruit firmness (gm/[illegible]$^2$) were realized by penetrometer Bertuzzi; Ascorbic acid concentration (mg/g FW); it extracted and titrated by 2.6-dichlorophenol indophenol as described by [32].

Photosynthetic pigments (chlorophylls a, b and total carotenoids), were extracted from the blade of the 3rd terminal upper compound leaf on the main stem for 24h at laboratory temperature by methanol after adding a trace from sodium carbonate, and determined spectrophotometrically [33]. For ion percentage; ground dried shoot samples were wet digested with $HClO_3/H_2SO_4$, cooled, and brought to the volume of 100 ml using deionized water and kept for ion determinations. Total nitrogen was determined by the micro-Kjeldahl method. Potassium was determined by a flame photometrically [34], and phosphorous using ammonium molybdate and ascorbic acid [35].

### Statistical analysis

Statistical analysis (ANOVA, least significant differences test) was performed at a probability level $P<0.05$. Percentage data were arcsine transformed before analysis [36].

## RESULTS AND DISCUSSION

### Vegetative growth characters

Data presented in table (1) show that vegetative growth represented as plant height, the number of branches per plant, as well as shoot fresh and dry weights were significantly increased under all mulching type as compared with bare soil in both experimental seasons. The highest values in plant height and branches number per plant in both season, as well as shoot fresh weight in the first season, were obtained due to the application of black plastic mulch (Bpm) as compared with bare soil (Bs). In contrast, the highest shoot dry weight in both seasons and plant fresh weight in the second season were obtained under the application of clear plastic mulch (Cpm) comparing with bare soil.

Regarding the effect of biostimulants or micronutrients on tomato plant growth, the data in the same table assessed that in most cases, all vegetative growth parameters were significantly increased due to the application of either biostimulants or micronutrient. Seaweed extract (Swe) proved to be more effective in this respect.

The interaction results proved that spraying application of biostimulants and micronutrient with mulch types significantly affected all growth and branches characters in the two experimental seasons when compared to control. The highest morphological parameters were recorded in most cases by application of 500 mg/l Swe under Cpm, meanwhile, the highest branches number per plant were recorded under the treatment of Swe plus Bpm in both seasons respectively.

**Table 1: Vegetative growth characters of tomato plants as affected by biostimulants and micronutrients with or without mulching type at 70 d from transplanting in both seasons**

| Characters Treatments | | Plant height(cm) | | Number of branches/plant | | shoot fresh weight (g) | | shoot dry weight (g) | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1stSeason | 2ndSeason | 1stSeason | 2ndSeason | 1stSeason | 2ndSeason | 1stSeason | 2ndSeason |
| Mulch (A) | Bs | 56.28 | 70.68 | 8.64 | 7.04 | 753.80 | 671.80 | 129.40 | 126.20 |
| | Cpm | 93.24 | 98.50 | 10.16 | 11.32 | 992.00 | 1057.40 | 179.60 | 183.00 |
| | Bpm | 96.60 | 99.72 | 10.48 | 12.12 | 1001.40 | 954.20 | 165.20 | 161.40 |
| | Sm | 91.44 | 94.44 | 9.88 | 10.34 | 905.80 | 917.80 | 149.40 | 156.40 |
| LSD at 5% | | 4.41 | 5.13 | 0.92 | 0.77 | 57.70 | 67.85 | 8.46 | 10.28 |
| Foliar spray (B) | W | 73.50 | 81.32 | 6.75 | 7.97 | 685.00 | 746.00 | 132.75 | 135.50 |
| | Swe | 92.30 | 98.40 | 11.25 | 11.87 | 1076.25 | 1065.00 | 171.25 | 180.25 |
| | Thi | 87.45 | 96.90 | 9.90 | 10.92 | 1030.00 | 936.25 | 173.50 | 159.50 |
| | Zn | 87.75 | 90.12 | 12.10 | 9.95 | 1033.00 | 912.25 | 168.25 | 158.75 |
| | Fe | 80.95 | 87.42 | 8.95 | 10.30 | 742.00 | 842.00 | 133.75 | 149.75 |
| LSD at 5% | | 4.94 | ns | 1.02 | 0.86 | 64.51 | ns | 9.46 | 11.50 |
| Interaction (A*B) | Bs+W | 53.00 | 60.80 | 6.60 | 6.10 | 514.00 | 538.00 | 104.00 | 108.00 |
| | Bs+Swe | 57.40 | 75.30 | 9.00 | 7.20 | 830.00 | 784.00 | 139.00 | 137.00 |
| | Bs+Thi | 56.60 | 83.80 | 9.40 | 8.40 | 910.00 | 625.00 | 149.00 | 124.00 |
| | Bs+Zn | 59.00 | 69.20 | 11.60 | 6.30 | 937.00 | 764.00 | 147.00 | 135.00 |
| | Bs+Fe | 55.40 | 64.30 | 6.60 | 7.20 | 578.00 | 648.00 | 108.00 | 127.00 |
| | Cpm+W | 75.00 | 85.40 | 6.40 | 8.60 | 685.00 | 752.00 | 145.00 | 142.00 |
| | Cpm+Swe | 106.40 | 110.80 | 12.00 | 13.30 | 1315.00 | 1380.00 | 210.00 | 230.00 |
| | Cpm+Thi | 96.60 | 105.30 | 9.40 | 11.70 | 1285.00 | 1160.00 | 222.00 | 190.00 |
| | Cpm+Zn | 98.60 | 92.50 | 11.40 | 10.40 | 950.00 | 1050.00 | 174.00 | 187.00 |
| | Cpm+Fe | 89.60 | 98.50 | 11.60 | 12.60 | 725.00 | 945.00 | 147.00 | 166.00 |
| | Bpm+W | 83.60 | 92.50 | 7.00 | 9.60 | 887.00 | 930.00 | 153.00 | 158.00 |
| | Bpm+Swe | 107.00 | 105.40 | 13.00 | 14.30 | 1125.00 | 976.00 | 175.00 | 165.00 |
| | Bpm+Thi | 103.60 | 100.060 | 11.00 | 12.20 | 1015.00 | 885.00 | 174.00 | 157.00 |
| | Bpm+Zn | 96.00 | 102.50 | 12.40 | 12.80 | 1075.00 | 940.00 | 172.00 | 155.00 |
| | Bpm+Fe | 92.80 | 97.60 | 9.00 | 11.70 | 905.00 | 1040.00 | 152.00 | 172.00 |
| | Sm+W | 82.40 | 86.60 | 7.00 | 7.60 | 654.00 | 764.00 | 129.00 | 134.00 |
| | Sm+Swe | 98.40 | 102.10 | 11.00 | 12.70 | 1035.00 | 1120.00 | 161.00 | 189.00 |
| | Sm+Thi | 93.00 | 97.90 | 9.80 | 11.40 | 910.00 | 1075.00 | 149.00 | 167.00 |
| | Sm+Zn | 97.40 | 96.30 | 13.00 | 10.30 | 1170.00 | 895.00 | 180.00 | 158.00 |
| | Sm+Fe | 86.00 | 89.30 | 8.60 | 9.70 | 760.00 | 735.00 | 128.00 | 134.00 |
| LSD at 5% | | 9.88 | 11.47 | 2.05 | 1.73 | 129.02 | 151.73 | 18.93 | 23.00 |

Bs=bare soil, Cpm=clear plastic mulch, Bpm=black plastic mulch, Sm=straw mulch, W=water, Swe=seaweed, Thi=thiamine, Zn= zinc, Fe= iron

Research over the past few years has demonstrated the stimulating effect of mulch type and shoot growth in different plants [37, 38]. In this concern, Wien [39] found that clear plastic mulch stimulated root extension, increased branching, increased concentration of major nutrients in the shoot. Additionally, Moursy *et al.* [4] on tomato plants found that, in general, mulches increased plant growth at 90 and 120 d from transplanting, the most effective in this concern was transparent plastic mulch. Moreover, mulching treatment had the highest stomatal conductance and leaf chlorophyll as well as increased photosynthetic rate that induced plant growth and increased plant fresh and dry weight [4].

The stimulating effect of biostimulants like seaweed extract on plant growth was previously reported [3, 16]. The promotive effects of biostimulants on plant growth are not yet explained, although there are some theories which probably work together, and can be summarised: 1) Biostimulants like Swe accelerate physiological processes in plants like macro-and micronutrient uptake, cell elongation, enzymatic activity and protein synthesis and finally inducing biomass production [11, 41]. Accordingly, it was found that application of biostimulants increased phosphorous percentage that plays an important role in the biosynthesis and translocation of carbohydrates and stimulation cell division as well as formation of DNA and RNA [24]. 2) Activate root cells and stimulate the biosynthesis of endogenous cytokinins [42]. Cytokinins known to promote cell division, inhibit leaf senescence by blocking the export of photosynthetic to new tissue and stimulating translocation of resources to treated leaves [24], 3) Stimulation the biosynthesis of antioxidants solutes, as in chloroplasts which protect chloroplast and stimulation of chlorophyll biosynthesis [14]. 4) The enriched content of Swe in crude protein and growth promoting hormones, in special, auxin and cytokinins [43]. Proteins are essential for the formation of protoplasm, while growth substances favored rapid cell division and cell multiplication as well as elongation. In addition, Abd El-Aziz Nahed *et al.*, [18] and Farouk [3] found that the application of thiamine and seaweed extract increased significantly vegetative growth represented as plant height, a number of leaves per plant, root length and leaf area, shoot FW and shoot dry weight.

The promotive effect of micronutrient on plant growth was confirmed by Seadh *et al.*, [21] and Farouk *et al.* [22]. The specific effect of each micronutrient may be summarized as a fellow. Foliar spraying with zinc improving the vegetative growth and including the plant capacity for building metabolites. Such response may be due to that zinc is known to play an activator of over 300 enzymes in plants [44] and is directly involved in the biosynthesis of auxin, Indole acetic acid in particular [45] which inducing more dry matter.

Application of Fe improved plant growth, in special, fresh and dry weight through its role in activating of chlorophyll biosynthesis and photosynthesis [46]. Along with the iron requirement in some heme enzymes and its involvement in the manufacture of the heme group in general, iron has a function in Fe-S proteins, which have a strong involvement with the light-dependent reactions of photosynthesis. As well as being the electron donor for the synthesis of NADPH in photosystem I, it can reduce nitrate in the reaction catalyzed by nitrite reductase and it is an electron donor for sulfite reductase. All these parameters might have contributed to optimum growth. Apart from this increased concentration of active Fe in the plants with these treatments enhanced the concentration of nitrogen in the plants. As physiologically active Fe play many roles in the metabolism of nitrogen within the plants by affecting the activities of nitrate reductase, which are directly involved in the assimilation of N and finally improving plant growth [47].

### Photosynthetic pigments

Table (2) shows that the highest values of total chlorophyll concentrations were obtained under the application of BPM plus water spraying and thiamin in bar soil in the first and second season respectively. Meanwhile, application of Zn or Fe under CPM gave the highest value of carotenoids in the first and second season respectively.

The present investigation indicated that there was a significant increase in chlorophyll Biostimulants elevated the potassium concentration (table, 3), which might have resulted in an increase in chloroplast per cell [24]. The role of Swe in increasing chlorophyll concentration may be due to containing considerable amounts of macro-and micro-nutrients, amino acids, vitamins and hormonal like activities [13, 48], and/or the high content of betains [49], which possibly increased chlorophyll concentration leading to higher rates of photosynthesis. These results were confirmed in tomato plant [50].

**Table 2: Photosynthetic pigment concentration (mg/g FW) in the 3rd upper terminal leaflet of tomato plants as affected by biostimulants and micronutrients with or without mulching type at 70 d from transplanting in both seasons**

| Characters | treatments | Chlorophyll A | | Chlorophyll B | | Total chlorophyll | | Total Carotenoids | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1stSeason | 2ndSeason | 1stSeason | 2ndSeason | 1stSeason | 2ndSeason | 1stSeason | 2ndSeason |
| Mulch (A) | Bs | 2.014 | 2.208 | 1.974 | 1.498 | 3.987 | 3.707 | 0.214 | 0.218 |
| | Cpm | 2.082 | 1.851 | 1.755 | 1.271 | 3.838 | 3.121 | 0.242 | 0.160 |
| | Bpm | 2.347 | 1.888 | **1.606** | 1.297 | 3.860 | 3.186 | 0.166 | 0.102 |
| | Sm | 1.950 | 2.059 | 1.786 | 1.334 | 3.738 | 3.395 | 0.258 | 0.138 |
| LSD at 5% | | 0.157 | 0.125 | 0.128 | ns | 0.240 | 0.074 | 0.008 | 0.005 |
| Foliar spray (B) | W | 2.342 | 1.777 | 1.735 | 1.186 | 4.079 | 2.961 | 0.169 | 0.192 |
| | Swe | 2.077 | 2.035 | 1.878 | 1.400 | 3.954 | 3.435 | 0.231 | 0.066 |
| | Thi | 2.465 | 2.283 | 1.696 | 1.521 | 4.162 | 3.806 | 0.126 | 0.078 |
| | Zn | 2.050 | 1.937 | 1.874 | 1.224 | 3.808 | 3.163 | 0.216 | 0.260 |
| | Fe | 1.723 | 1.976 | 1.552 | 1.420 | 3.276 | 3.396 | 0.359 | 0.176 |
| LSD at 5% | | 0.174 | ns | 0.142 | 0.140 | 0.268 | 0.082 | 0.008 | 0.005 |
| Interaction (A*B) | Bs+W | 2.201 | 1.697 | 1.894 | 1.085 | 4.096 | 2.784 | 0.181 | 0.100 |
| | Bs+Swe | 2.020 | 2.372 | 1.819 | 1.631 | 3.832 | 4.003 | 0.184 | 0.044 |
| | Bs+Thi | 2.411 | 2.526 | 1.880 | 1.662 | 4.291 | 4.189 | 0.123 | 0.054 |
| | Bs+Zn | 2.227 | 2.361 | 1.721 | 1.574 | 3.949 | 3.935 | 0.406 | 0.750 |
| | Bs+Fe | 2.228 | 2.087 | 1.543 | 1.541 | 3.771 | 3.628 | 0.177 | 0.146 |
| | Cpm+W | 2.184 | 1.579 | 1.277 | 0.987 | 3.462 | 2.556 | 0.295 | 0.255 |
| | Cpm+Swe | 1.919 | 2.171 | 1.682 | 1.598 | 3.601 | 3.769 | 0.247 | 0.051 |
| | Cpm+Thi | 2.710 | 1.958 | 1.839 | 1.425 | 4.549 | 3.384 | 0.069 | 0.039 |
| | Cpm+Zn | 2.368 | 1.905 | 1.851 | 1.080 | 4.220 | 2.986 | 0.062 | 0.093 |
| | Cpm+Fe | 1.890 | 1.642 | 1.470 | 1.269 | 3.360 | 2.912 | 0.541 | 0.365 |
| | Bpm+W | 1.786 | 2.005 | 1.270 | 1.449 | 3.056 | 3.453 | 0.083 | 0.168 |
| | Bpm+Swe | 2.271 | 1.588 | 1.818 | 1.059 | 4.090 | 2.647 | 0.387 | 0.083 |
| | Bpm+Thi | 2.270 | 2.345 | 1.540 | 1.531 | 3.801 | 3.876 | 0.122 | 0.099 |
| | Bpm+Zn | 2.259 | 1.786 | 1.631 | 1.160 | 3.422 | 2.947 | 0.059 | 0.100 |
| | Bpm+Fe | 2.145 | 1.719 | 1.521 | 1.290 | 3.766 | 3.009 | 0.182 | 0.060 |
| | Sm+W | 2.086 | 1.829 | 1.876 | 1.223 | 3.965 | 3.054 | 0.118 | 0.247 |
| | Sm+Swe | 2.195 | 2.010 | 1.795 | 1.313 | 3.990 | 3.324 | 0.106 | 0.086 |
| | Sm+Thi | 1.706 | 2.304 | 1.471 | 1.466 | 3.178 | 3.776 | 0.193 | 0.123 |
| | Sm+Zn | 1.854 | 1.699 | 1.788 | 1.085 | 3.643 | 2.784 | 0.338 | 0.100 |
| | Sm+Fe | 2.280 | 2.457 | 1.328 | 1.580 | 3.609 | 4.083 | 0.536 | 0.134 |
| LSD at 5% | | 0.348 | 0.285 | 0.288 | 0.282 | 0.540 | 0.165 | 0.020 | 0.014 |

Bs=bare soil, Cpm=clear plastic mulch, Bpm=black plastic mulch, Sm=straw mulch, W=water, Swe=seaweed, Thi=thiamine, Zn= zinc, Fe= iron

Fe plays important role in plant growth and development [46] by activating the enzymes aminolevulinic acid synthetase and coproporphyrinogen oxidase or by its role in the conversion of Mg protoporphyrin to protochlorophyide [51]. Recently, Ozer [4] on tomato confirmed by the present investigation which indicated that all mulch type increased leaf chlorophyll content

### Ion content

Mulching type significantly increased ion percentage in the tomato shoot as compared with bare soil (table 3). The highest nitrogen percentage (0.323 and 0.331% in both seasons) was obtained due to Bpm application, meanwhile, the highest percentage of phosphorous (0.298 and 0.307%) and potassium (1.432 and 1.440%) was obtained under Cpm comparing with bare soil.

The data also indicated that, using of either biostimulants or micronutrient, in special, seaweed extract without mulching significantly increased ion percentage in the tomato shoot as compared with untreated plants. Spraying Swe treatment proved to be the most effective in this respect. Data also proved that biostimulants application and/or micronutrients with mulch significantly increased ion percentage in the shoot compared with untreated control plants. The highest percentage of this concern was spraying Swe plus Bpm or Cpm in both seasons for N and either potassium or phosphorous. The promotive effect of biostimulants in ion % is not fully understood. It may be resulted from improving root system growth, increasing proliferation of root hairs, production of smaller and more ramified lateral roots [52] and to stabilizing membrane permeability, additionally improving nitrogen use efficiency by retarded nitrification processes or inhibited urease activity [53]. Recently, Castaings *et al.* [54] indicated that application of Swe enhanced nitrogen assimilation. Similarly, Grubinger *et al.* [55] indicate that clear plastic mulch application increased phosphorous concentration in leaf tissue.

### Yield and fruit quality

Data in table (4) shows that mulching type's significantly increased total yield as well as marketable fruit yield meanwhile decreased un-marketable fruit as compared with bare soil. Foliar application of either biostimulants or micronutrients significantly increased tomato yield compared with untreated control plants. The most effective in this concern was seaweed extract. Moreover, the table proved that application of Swe under Cpm gave the highest tomato yield per plant (4.4 and 4.25 kg/plant).

**Table 3: Ion percentage of tomato shoots as affected by biostimulant and micronutrients with or without mulching type at 70 d from transplanting in both seasons**

| Characters | | Nitrogen | | Phosphorous | | Potassium | |
|---|---|---|---|---|---|---|---|
| treatments | | 1st Season | 2nd Season | 1st Season | 2nd Season | 1st Season | 2nd Season |
| Mulch (A) | Bs | 0.125 | 0.133 | 0.206 | 0.221 | 1.062 | 1.074 |
| | Cpm | 0.298 | 0.306 | 0.298 | 0.307 | 1.432 | 1.440 |
| | Bpm | 0.323 | 0.331 | 0.245 | 0.251 | 1.324 | 1.333 |
| | Sm | 0.723 | 0.281 | 0.256 | 0.261 | 1.297 | 1.303 |
| LSD at 5% | | 0.125 | 0.125 | 0.017 | 0.017 | 0.097 | 0.097 |
| Foliar spray (B) | W | 0.076 | 0.083 | 0.175 | 0.184 | 0.912 | 0.920 |
| | Swe | 0.614 | 0.622 | 0.321 | 0.330 | 1.552 | 1.561 |
| | Thi | 0.296 | 0.302 | 0.289 | 0.297 | 1.480 | 1.488 |
| | Zn | 0.177 | 0.188 | 0.247 | 0.255 | 1.357 | 1.366 |
| | Fe | 0.110 | 0.118 | 0.226 | 0.234 | 1.092 | 1.101 |
| LSD at 5% | | 0.120 | 0.120 | 0.020 | 0.020 | ns | ns |
| Interaction (A*B) | Bs+W | 0.065 | 0.074 | 0.141 | 0.155 | 0.721 | 0.733 |
| | Bs+Swe | 0.238 | 0.245 | 0.276 | 0.290 | 1.410 | 1.422 |
| | Bs+Thi | 0.162 | 0.168 | 0.234 | 0.250 | 1.310 | 1.322 |
| | Bs+Zn | 0.106 | 0.117 | 0.212 | 0.226 | 1.100 | 1.112 |
| | Bs+Fe | 0.055 | 0.063 | 0.171 | 0.185 | 0.770 | 0.782 |
| | Cpm+W | 0.067 | 0.073 | 0.240 | 0.248 | 1.300 | 1.008 |
| | Cpm+Swe | 0.719 | 0.726 | 0.397 | 0.407 | 1.770 | 1.778 |
| | Cpm+Thi | 0.349 | 0.355 | 0.312 | 0.319 | 1.600 | 1.608 |
| | Cpm+Zn | 0.220 | 0.231 | 0.274 | 0.282 | 1.460 | 1.468 |
| | Cpm+Fe | 0.139 | 0.147 | 0.271 | 0.279 | 1.330 | 1.338 |
| | Bpm+W | 0.095 | 0.098 | 0.161 | 0.167 | 0.951 | 0.960 |
| | Bpm+Swe | 0.916 | 0.925 | 0.276 | 0.282 | 1.540 | 1.549 |
| | Bpm+Thi | 0.334 | 0.340 | 0.309 | 0.315 | 1.540 | 1.549 |
| | Bpm+Zn | 0.173 | 0.184 | 0.253 | 0.259 | 1.460 | 1.469 |
| | Bpm+Fe | 0.100 | 0.108 | 0.229 | 0.235 | 1.130 | 1.139 |
| | Sm+W | 0.080 | 0.088 | 0.161 | 0.166 | 0.976 | 0.982 |
| | Sm+Swe | 0.586 | 0.593 | 0.336 | 0.341 | 1.490 | 1.496 |
| | Sm+Thi | 0.342 | 0.348 | 0.302 | 0.307 | 1.470 | 1.476 |
| | Sm+Zn | 0.212 | 0.223 | 0.250 | 0.255 | 1.410 | 1.416 |
| | Sm+Fe | 0.148 | 0.156 | 0.235 | 0.240 | 1.140 | 1.146 |
| LSD at 5% | | ns | Ns | 0.040 | 0.040 | 0.217 | 0.217 |

Bs=bare soil, Cpm=clear plastic mulch, Bpm=black plastic mulch, Sm=straw mulch, W=water, Swe=seaweed, Thi=thiamine, Zn= zinc, Fe= iron

**Table 4: Tomato yield as affected by biostimulants and micronutrients with or without mulching type at 110 d from transplanting in both seasons**

| Characters treatments | | Red fruits weight (gm) | | Colored fruits weight (gm) | | Total yield/plant (kg) | |
|---|---|---|---|---|---|---|---|
| | | 1stSeason | 2ndSeason | 1stSeason | 2ndSeason | 1stSeason | 2ndSeason |
| Mulch (A) | Bs | 2205 | 2118 | 580 | 570 | 2.78 | 2.68 |
| | Cpm | 3013 | 3149 | 470 | 429 | 3.48 | 3.53 |
| | Bpm | 2984 | 2871 | 331 | 344 | 3.31 | 3.21 |
| | Sm | 2941 | 2720 | 642 | 428 | 3.60 | 3.14 |
| LSD at 5% | | 460 | 241 | 90 | 30 | 0.29 | 0.12 |
| Foliar spray (B) | W | 2129 | 2190 | 395 | 335 | 2.52 | 2.52 |
| | Swe | 3405 | 3211 | 666 | 653 | 4.07 | 3.79 |
| | Thi | 3155 | 2977 | 449 | 385 | 3.62 | 3.36 |
| | Zn | 2770 | 2731 | 582 | 440 | 3.35 | 3.18 |
| | Fe | 2470 | 2462 | 436 | 400 | 2.90 | 2.86 |
| LSD at 5% | | ns | ns | 101 | 34 | 0.32 | 0.13 |
| Interaction (A*B) | Bs+W | 1985 | 1860 | 360 | 340 | 2.34 | 2.20 |
| | Bs+Swe | 2335 | 2150 | 1015 | 970 | 3.35 | 3.12 |
| | Bs+Thi | 2405 | 226 | 545 | 460 | 2.95 | 2.72 |
| | Bs+Zn | 2195 | 2340 | 710 | 630 | 2.90 | 2.97 |
| | Bs+Fe | 2105 | 1980 | 270 | 450 | 2.37 | 2.43 |
| | Cpm+W | 1935 | 2420 | 480 | 370 | 2.41 | 2.79 |
| | Cpm+Swe | 3630 | 378 | 825 | 735 | 4.45 | 4.25 |
| | Cpm+Thi | 3470 | 3520 | 318 | 430 | 3.78 | 3.95 |
| | Cpm+Zn | 3190 | 2970 | 410 | 350 | 3.60 | 3.38 |
| | Cpm+Fe | 2840 | 3050 | 320 | 260 | 3.16 | 3.31 |
| | Bpm+W | 2156 | 1950 | 420 | 360 | 2.58 | 2.31 |
| | Bpm+Swe | 3910 | 3670 | 340 | 640 | 4.25 | 4.31 |
| | Bpm+Thi | 3520 | 3160 | 290 | 160 | 3.81 | 3.32 |
| | Bpm+Zn | 2760 | 2945 | 371 | 250 | 3.13 | 3.19 |
| | Bpm+Fe | 2565 | 2630 | 235 | 310 | 2.80 | 2.94 |
| | Sm+W | 2433 | 2530 | 323 | 270 | 2.75 | 2.80 |
| | Sm+Swe | 3745 | 3240 | 485 | 270 | 4.23 | 3.51 |
| | Sm+Thi | 3225 | 2970 | 645 | 490 | 3.97 | 3.46 |
| | Sm+Zn | 2935 | 2670 | 840 | 530 | 3.77 | 3.20 |
| | Sm+Fe | 2370 | 2190 | 920 | 580 | 3.29 | 2.77 |
| LSD at 5% | | 1028.97 | 540.53 | 203.04 | 68.11 | 0.66 | 0.27 |

Bs=bare soil, Cpm=clear plastic mulch, Bpm=black plastic mulch, Sm=straw mulch, W=water, Swe=seaweed, Thi=thiamine, Zn= zinc, Fe= iron, concerning fruit quality, table (5) indicates that were detected under Bpm. Also, Cpm gave the high value of T. s. s in both seasons.

Similar results were reported by erlier works [4, 8, 5, 6]. Samaila *et al.* [57] indicated that soil mulching significantly increased the total yield of tomato fruits compared with bare soil (Bs). Similarly, [58] found that all organic mulches applied in their experiment caused an increase in tomato yield. According to Sinkevičienė *et al.* [59], yield level of vegetables significantly related to the kind of mulch applied to the soil. The authors added that soil, mulching with grass had the highest yielding effect. This results are in agreement with previous reports [61, 62]. Majkowska-Gadomska *et al.* [63] and Gajc-Wolska *et al.* [64] found that sweet pepper fruits cultivated on mulch with straw contained significantly more vitamin C compared to those cultivated on polypropylene fiber mulch.

Micronutrients like Fe or Zn are important in growth and fruit development [51]. Additionally, Zn application has a favorable effect on pollen germination, tube elongation and increasing the number of ruptured pollen that results in better fertilization, higher fruit set and final yield [24]. Previous studies support our findings in this study [65-69].

Concerning yield quality, it is well documented from the present study that foliar application of biostimulants accelerated fruit quality. These results were confirmed by [3, 11]. The favorable influences of biostimulants on the chemical characteristics of tomato fruit may be ascribed to its stimulative effect on photosynthesis process and its concentration of some promoter hormones such as cytokinins which are closely involved in cell division, protein, carbohydrates, and chlorophyll formation [70]. Arafa *et al.* [71] found that foliar application of seaweed extract has resulted in an increase in potato tuber quality represented as total acidity, total soluble solids and ascorbic acid content. The stimulation effect of biostimulants and micronutrient with or without mulch on tomato yield could be attributed to the presence of plant growth substances, in special, cytokinins in Swe [13], that induced overall plant growth, maintenance of green leaves, and number of branches per plant, increasing photosynthetic pigments as well (table 3), followed by increasing sink capacity fulfilled supply of photoassimilates from green leaves and/or re-translocation of stem reserve [68]. Ozer [4] proved that all mulching type increased tomato yield, fruit firmness and decreased soluble solid content and titratable acidity.

**Table 5: Tomato fruit quality as affected by biostimulants and micronutrients with or without mulching type at 110 d from transplanting in both seasons**

| Characters treatments | | Fruit firmness (gm/$cm^2$) | | Total soluble solids T. S. S % | | Ascorbic acid (mg/g) | |
|---|---|---|---|---|---|---|---|
| | | 1st Season | 2nd Season | 1st Season | 2nd Season | 1st Season | 2nd Season |
| Mulch (A) | Bs | 3.98 | 4.26 | 6.00 | 6.00 | 1.52 | 1.40 |
| | Cpm | 4.26 | 4.06 | 6.44 | 6.18 | 1.56 | 1.84 |
| | Bpm | 4.30 | 4.26 | 6.24 | 5.84 | 2.04 | 1.69 |
| | Sm | 4.14 | 4.10 | 6.12 | 5.48 | 1.64 | 1.18 |
| LSD at 5% | | ns | 0.208 | 0.265 | 0.288 | 0.114 | 0.102 |
| Foliar spray (B) | W | 4.32 | 4.32 | 5.50 | 5.30 | 1.92 | 1.58 |
| | Swe | 4.00 | 4.00 | 6.60 | 6.25 | 1.52 | 1.39 |
| | Thi | 4.15 | 4.20 | 6.35 | 5.75 | 1.56 | 1.28 |
| | Zn | 4.32 | 4.37 | 6.50 | 6.22 | 1.65 | 1.53 |
| | Fe | 4.05 | 3.95 | 6.05 | 5.85 | 1.80 | 1.89 |
| LSD at 5% | | Ns | ns | 0.297 | 0.322 | 0.128 | 0.117 |
| Interaction (A*B) | Bs+W | 3.80 | 4.00 | 5.40 | 5.00 | 1.40 | 1.40 |
| | Bs+Swe | 3.90 | 4.10 | 6.20 | 5.80 | 1.00 | 1.60 |
| | Bs+Thi | 3.40 | 4.80 | 6.40 | 5.40 | 1.20 | 0.96 |
| | Bs+Zn | 3.20 | 4.60 | 6.20 | 5.80 | 2.08 | 1.48 |
| | Bs+Fe | 3.60 | 3.80 | 5.80 | 5.40 | 1.92 | 1.60 |
| | Cpm+W | 4.40 | 4.20 | 5.80 | 5.40 | 1.68 | 2.24 |
| | Cpm+Swe | 4.40 | 4.20 | 6.80 | 6.40 | 1.80 | 1.20 |
| | Cpm+Thi | 4.20 | 4.00 | 6.20 | 5.40 | 1.64 | 1.64 |
| | Cpm+Zn | 4.30 | 4.10 | 6.80 | 6.60 | 1.20 | 1.80 |
| | Cpm+Fe | 4.00 | 3.80 | 6.60 | 6.20 | 1.48 | 2.36 |
| | Bpm+W | 4.50 | 4.70 | 5.60 | 5.80 | 2.36 | 1.36 |
| | Bpm+Swe | 4.10 | 3.90 | 6.60 | 6.40 | 2.08 | 1.96 |
| | Bpm+Thi | 4.20 | 4.00 | 6.40 | 6.00 | 1.48 | 1.32 |
| | Bpm+Zn | 4.40 | 4.60 | 6.40 | 6.30 | 1.92 | 1.60 |
| | Bpm+Fe | 4.30 | 4.10 | 6.20 | 6.40 | 2.36 | 2.24 |
| | Sm+W | 4.60 | 4.40 | 5.20 | 5.00 | 2.24 | 1.32 |
| | Sm+Swe | 3.60 | 3.80 | 6.80 | 6.40 | 1.20 | 0.80 |
| | Sm+Thi | 3.80 | 4.00 | 6.40 | 6.20 | 1.92 | 1.20 |
| | Sm+Zn | 4.40 | 4.20 | 6.60 | 6.20 | 1.40 | 1.24 |
| | Sm+Fe | 4.30 | 4.10 | 5.60 | 5.40 | 1.44 | 1.36 |
| LSD at 5% | | 0.500 | 0.465 | ns | 0.648 | 0.260 | 0.234 |

Bs=bare soil, Cpm=clear plastic mulch, Bpm=black plastic mulch, Sm=straw mulch, W=water, Swe=seaweed, Thi=thiamine, Zn= zinc, Fe= iron

## CONCLUSION

From the results it is clear that plastic mulches benefit the growth, and yield of tomato and clear plastic showed superior performance among the plastic mulches and use of Cpm plus spraying tomato plants with 500 mg Swe at 35, 50 d after transplanting give high marketable fruit.

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