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Soil Drenching and Foliar Application of Nutrient based Biostimulants on Growth, and Morphometric Traits of Tomato under Water Limited Condition

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ABSTRACT: Water deficit is one of the most common a biotic stress factors affecting crop production globally. Indiscriminate usage of agrochemicals and fertilizers in vegetable production leads to many ecological issues. To minimize the excessive usage of chemical fertilizers, plant based growth promoting products like biostimulants are extensively used in the present days. Nutrient based biostimulants represents a group of environmental practices intended to improve crop stress tolerance and to mitigate the adverse effects on crop productivity. In this study, foliar application of *Orthol-O2*, a biostimulant based on Ortho-silicic acid (OSA) and soil drenching of *Talete 20*, a seaweed extract (SE) were studied on tomato plants grown under water limited condition. The plants were exposed to water limited condition (80% of the water given to treatment plants) after crop establishment stage. The response of biostimulants was recorded at 45-55 days after transplantation (DAT) and 55-65 DAT intervals. It is observed that plants grown under drought conditions and treated with the biostimulants had increased plant height, number of leaves, leaf area and leaf area index, relative water content and total dry matter production compared to untreated plants under drought stress. The experiment revealed that use of biostimulants is a viable option to improve the growth and morphometric traits of tomato plants under water limited conditions status.

Keywords: Tomato, drought, biostimulants, Ortho-silicic acid, growth, and morphometric traits.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is the world's second most important vegetable, and is commonly cultivated in tropical climates. Over the last decade, total tomato production has gradually increased to 182.25 million tonnes fresh fruit in 2018 (FAOSTAT, 2020). Because of its rich nutritional profile, which includes vitamins, folate, and phytochemicals, it is utilized as a fresh or canned meal (Aldrich *et al.,* 2010). Among the most serious abiotic stress limiting agricultural yield, water scarcity is the major threat. Water stress decreases vegetative development alters phenology, and affecting reproduction in tomato. To overcome these constraints, use of compounds like biostimulants has been a favorable strategy for sustained growth by influencing plant architectural traits.

Biostimulants, extracts derived from organic raw materials containing bioactive chemicals are gaining popularity in sustainable agriculture as they activate a number of physiological mechanisms that stimulate plant growth and development, improve nutrient usage efficiency, and reduce fertilizer use. Biostimulants are compounds unlike fertilizers, encourage plant growth when used in small amounts (Kunicki *et al.,* 2010). It also enhances soil health by encouraging the production of beneficial soil microbes, which boosts root and shoot growth, and water uptake. Biostimulants can be applied through foliar application or soil/substrate drenching. When biostimulants are sprayed on theleaves, it is absorbed through the cuticle, epidermal cells and stomata (Fernández and Eichert, 2009); instead with drenching technique, it is absorbed through root epidermal cells and gets redistributed through the xylem (Subbarao *et al.,* 2015). Biostimulantscan modify the primary and secondary metabolism of plants, improving productivity and decreasing the impact of abiotic stress on crops (Calvo *et al.,* 2014; Rouphael *et al.,* 2017).

Seaweed extracts are nutrient supplements in agriculture and horticulture to boost plant growth and productivity as an alternative to chemical fertilizers. Seaweed extracts are rich in mineral elements like calcium, magnesium, potassium, chlorine, sulphur, phosphorous, iodine, zinc and copper. Brown seaweed extracts are widely utilized in horticultural crops for their plant growth-promoting properties as well as for improving crop tolerance to abiotic stresses including salt, high temperatures, nutrient shortage, and drought (Battacharyya *et al.,* 2015).

Silicon (Si), the second most common element in the earth's crust, is typically found in the form of complex silicates or metasilicates. It catalyses numerous biochemical activities inside plants as silicic acid, whereas polymerized silicic acid integrates securely into the structural materials and offers mechanical strength, as well as acting as a physical barrier against insect pest and disease infestation. In most crops, silicon (Si) is efficient in alleviating both abiotic and biotic stresses (Yoshida, 1975). Despite the fact that numerous publications on the utilization of seaweed extract and silicon in plant culture are accessible, there has been little study on drought studies. This study assesses the effects of nutrient based biostimulants to improve plant growth in terms of different architectural traits, under water limited condition.

MATERIALS AND METHODS

The field experiment was conducted in field no. 75, Eastern Block Farm, Tamil Nadu Agricultural University (TNAU), Coimbatore, which is being located at 11°N latitude and 77°E longitude at an altitude of 426.7 m above mean sea level. Basal application was done before transplanting and plant protection measures were carried out as per the recommendations of TNAU Crop Production Guide. At the time of transplanting, clayey loam soil of experimental field had pH 8.6, EC 0.31dS/m, nitrogen (N)-199 kg ha^{-1}, phosphorus (P)-23 kg ha^{-1} and potassium (K)-927 kg ha^{-1}. During the experimental duration, the crop was given the fertilizer in 50:250:100 kg ha^{-1} in three splits, full phosphorous and potassium along with one-third nitrogen as basal dose and remaining nitrogen in two splits after 30 DAT and 45DAT.

Twenty one day old seedling of tomato hybrid Shivam were transplanted in randomized block design in the month of July 2021 to study the effect of soil drenching or foliar application of Seaweed extract (*Talete 20*) and Ortho-silicic acid (*Orthol-O2*) respectively, at different tomato fruit developmental stages (45-55 DAT and 55-65 DAT). *Talete 20* was applied in different doses @ 5L ha^{-1} of four applications and 10L $ha^{-1}$of two applications. *Orthol-O2* was given as foliar spray@0.1% and 0.5% of one application. There were six treatments in the experiment *viz.,* T1: 100% water (Control), T2: 80 % water (Treatment control), T3: 80% water + *Talete 20* - 5L ha^{-1} (soil drenching), T4: 80% water + *Talete 20*- 10L ha^{-1} (soil drenching), T5: 80% water + *Orthol-O2*- 0.1% (foliar spray), T6: 80% water + *Orthol-O2* - 0.5% (foliar spray). Drought was imposed at crop establishment stage (i.e. after transplanting shock) and continued till harvest. Irrigation water was calculated using V-notch equipment, through which drought was imposed for 80% irrigation treatments. As tomato crop water depth is 50mm, to reach 50mm of water depth water is allowed for 3 minutes at speed 2.5L sec^{-1} (calculated using LMNO engineering, research and software, Ltd) in control plot (100% irrigation) whereas, in treatment plots (80% irrigation)water is allowed only for 2.4 minutes at same speed. Commercially available bio-stimulants namely, *Talete 20* (Seaweed extracts)and *Orthol-O2* (Ortho-silicic acid) were used for this study.

Plant height was measured from ground level to tip of the top most leaf and denoted in centimeter (cm).

Numbers of leaves were determined by counting the leaves from the base to tip of the plant in each replication and the mean value expressed in numbers.

Leaf samples collected from each replication were cleaned well and inserted into leaf area meter (LICOR, Model LI 3000) and leaf area was measured. The value was expressed as cm^2 per plant. The leaf area index of the plant was computed as per the procedure suggested by (Williams, 1946) by using the following formula

$$\text{LAI} = \frac{\text{Total leaf area of the plant}}{\text{Ground area occupied by the plant (spacing)}}$$

Specific leaf weight of the samples were computed according to Nelson and Schweitzer (1988) by using the formula,

$$\text{SLW} = \frac{\text{Leaf dry weight}}{\text{Leaf area}}$$

The value was expressed as mg/cm^2.

The Relative Water Content (RWC) was estimated according to Barrs and Weatherly (1962) and calculated by using following formula and expressed as per cent.

RWC = [(Fresh weight – Dry weight)/(Turgid weight – Dry weight)] × 100

To assess the total dry matter production, plants were pulled out from the field and roots were washed to get rid of soil. The plant samples were dried in a shade place and kept in an oven for 48 hours at 80°C. The value was expressed as g $plant^{-1}$. The recorded data were subjected to Analysis of Variance and DMRT (Duncan, 1955) at P = 0.05 was used to compare treatment means.

RESULTS AND DISCUSSION

Plant height is one of the important architectural traits which are highly correlated with biomass production and yield potential. From the Fig. 1a, we could conclude that under water limited condition there is significant reduction in plant height when compared to control. Reduced plant height might be due to reduction in cell turgor causing reduced cell division and cell elongation. Biostimulant *Talete 20* - 10L ha^{-1} and *Orthol-O2* - 0.5% showed significant increase in plant height compared to all treatments in both the intervals. Our results are in accordance with Taha *et al.,* (2020); El-Gamal *et al.* (2020); Ibrahim *et al.,* (2018). Increased plant height under biostimulants might be due to their influence on cell metabolism and improved nutrient uptake.

Leaves are the source tissue for the photosynthesis to take place;increase in number of leaves increases carbon accumulation which directly contributing to crop yield. From the Fig. 1b, we could observe that under water limited condition there is reduction in leaf numbers which might be due to reduced due to altered cell turgor resulting in reduced cell division and cell elongation. The maximum number of leaves was observed in *Talete 20* - 10 L ha^{-1} and *Orthol-O2* - 0.5% at both the interval when compared to treatment control. There was an increase in number of leaves by 10.8% and 9.56% due to *Talete 20* - 10 L ha^{-1} and *Orthol-O2* - 0.5% in 55-65 DAT intervals. The presence of growth-promoting substances in seaweed extract, such as macro and micro nutrient contributed for increasing the number of leaves under drought stress through maintenance of plant water status and silicon like compounds might modify C: N: P stoichiometry, thereby increasing use efficiency of these nutrients which directly contributes to increased leaf number. The observations in the present study are in corroboration with the findings of El-Gamal *et al.*, (2020); Mansori *et al.*, (2015).

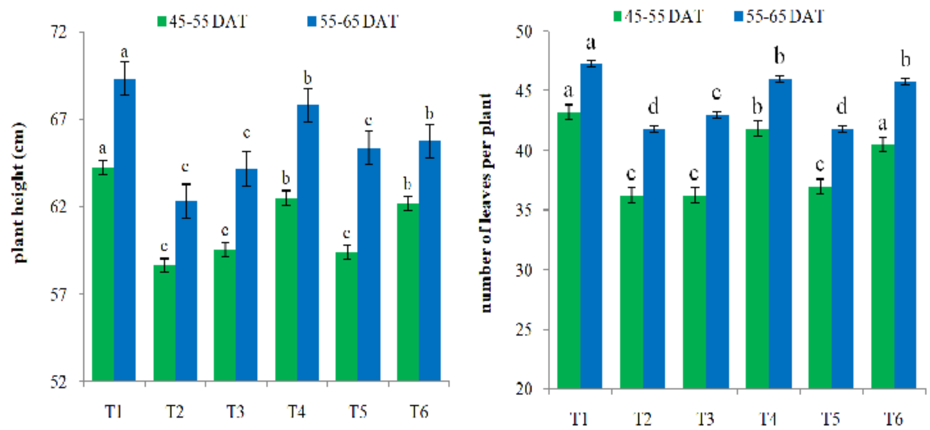

Fig. 1. Effect of biostimulants on (a) Plant height, and (b) Number of leaves under water deficit condition. Each value is the mean of four replicates. Mean values with the same letter are not significantly different at P=0.05 by DMRT. (T1:100% water (Control); T2: 80% water (Treatment control); T3: 80% water + *Talete 20* - 5L ha^{-1}; T4: 80% water + *Talete 20* - 10L ha^{-1}; T5: 80 % water + *Orthol-O2* - 0.1%; T6: 80% water + *Orthol-O2* - 0.5%)

Leaf area and leaf area index (LAI) are the primary variables that affect net photosynthesis and total dry matter production of the plants. This indicates the amount of leaf area produced per unit of land area. In our present study, under water limited condition there is reduction in leaf area and leaf area index. Results from Fig. 2. disclosed that application of biostimulants *Talete 20* - 10 L ha^{-1} and *Orthol-O2* - 0.5% showed increased leaf area and leaf area index in both the intervals of observation. The results are in accordance with findings of Asgharipour and Masapour, (2016) as silicon foliar spray under water deficit condition showed positive interaction of leaf area index. Biostimulants improved the plant nutritional status, as a result of increased allocation of assimilates for leaf development, resulting in higher leaf weight values or leaf area (Porter, 1989).

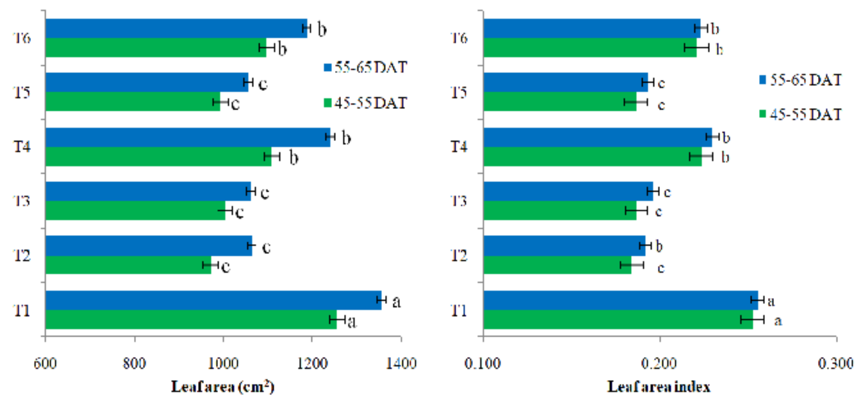

Fig. 2. Effect of biostimulants on (a) Leaf area, (b) Leaf area index under drought stress. Each value is the mean of four replicates. Mean values with the same letter are not significantly different at P=0.05 by DMRT. (T1:100% water (Control); T2: 80% water (Treatment control); T3: 80% water + *Talete 20* - 5L ha^{-1}; T4: 80% water + *Talete 20* - 10L ha^{-1}; T5: 80% water + *Orthol-O2* - 0.1%; T6: 80% water + *Orthol-O2* - 0.5%)

Specific leaf weight indicates how much of biomass is produced per unit area. From the Table 1. It is observed that there is no significant difference among the treatments. Plants with biostimulants or no biostimulants under water limited showed similar results on specific leaf weight. The present results are in contradiction with Jain *et al.*, (2018) in sugarcane under normal condition and (Umapathi *et al.*, 2021) in sorghum under water limited condition.

Table 1: Effect of biostimulants on specific leaf weight, relative water content and total dry matter production under drought stress. Each value is the mean of four replicates. Mean values with the same letter are not significantly different at P=0.05 by DMRT. (T1:100% water (Control); T2: 80% water (Treatment control); T3: 80% water + *Talete 20* - 5L ha^{-1}; T4: 80% water + *Talete 20* - 10L ha^{-1}; T5: 80% water + *Orthol-O2* - 0.1%; T6: 80% water + *Orthol-O2* - 0.5%).

Treatments	**Specific leaf weight (mg cm^{-2})**		**Relative water content (%)**		**Total dry matter production (g plant^{-1})**	
	45-55 DAT	**55-65 DAT**	**45-55 DAT**	**55-65 DAT**	**45-55 DAT**	**55-65 DAT**
T1:100 % water (Control)	8.24a	8.99a	78.75a	76.75a	31.69a	46.10a
T2:80 % water (Treatment control)	7.44a	8.57a	69.75c	65.75c	26.13c	40.28c
T3:80% water + *Talete 20* - 5L ha^{-1}	7.49a	8.69a	71.25c	67.75bc	26.77c	41.31c
T4:80% water + *Talete 20*- 10L ha^{-1}	7.99a	8.82a	75.50b	71.75b	29.44b	43.87b
T5:80% water + *Orthol-O2* - 0.1%	7.46a	8.59a	71.00c	66.75bc	26.69c	41.17c
T6:80 % water + *Orthol-O2* - 0.5%	8.03a	8.90a	76.00b	71.00b	29.05b	43.09b
SE(d)	0.1955	0.1387	0.5854	1.1018	0.1847	0.2694
CD (P=0.05)	0.3427	0.2431	1.0262	1.9315	0.3237	0.47227

Total dry matter production (TDMP) is strongly correlated with photosynthesis and yield. In our present study, under water limited situation there is significant reduction in total dry matter production due to reduced photosynthetic area and improper allocation of assimilates. In 45-55 DAT interval, application of biostimulants *Talete 20* - 10 L ha^{-1} (20.44g) and *Orthol-O2* - 0.5% (20.31g) doses showed higher biomass production whereas, in 55-65 DAT interval biostimulants at *Talete 20* - 10 L ha^{-1} improved maximum biomass (56.73g). The results are in accordance with the findings of Hattori *et al.*, (2005) and Shahriari *et al.*, (2021). Biostimulants improved the total dry matter production probably through increasing the hormones like auxin and cytokinin activity in plant metabolism.

Relative water content (RWC) is recognized as a most relevant index for dehydration tolerance since it measures plant water status that reflects metabolic activity in tissues. The maximum RWC was observed in control by registering (78.75% and 76.75%) observed on 45-55 DAT and 55-65 DAT. Under water limited condition there was significant reduction in RWC when the plants were not treated with biostimulants. The biostimulant *Talete 20* - 10 L ha^{-1} and *Orthol-O2* - 0.5% enhanced the RWC by registering (75.50% and 76.00%) at 45-55 DAT. The results are in accordance with the findings of Kusvuran, (2021); Ghouri *et al.*, (2021). Relative water content is closely related to water uptake by the roots as well as water loss by transpiration. Plants treated with biostimulants might have controlled the leaf transpiration, causing increased leaf water content in relation to treatment control.

CONCLUSION

The present research concludes that soil drenching or foliar application of plant or nutrient based biostimulants improve morphometric parameters and plant growth under water limited condition, especially when seaweed extract or silicic acid are applied. The improved growth might be due to biostimulants effective nutrient utilization for enhanced plant metabolism.

FUTURE SCOPE

The use of *Talete 20* and *Orthol-O2* is a sustainable approach to improve the crop growth for better yield under water limited condition in tomato. Assessing the effects of biostimulants in different crops at appropriate growth stages might be a viable option to enhance or sustain the crop yield under stress environments.

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Conflict of interest. There is no conflict of interest among the authors.

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