EFFECT OF SILICON ON QUALITY PARAMETERS OF TOMATO (*Solanum lycopersicum*) IN WATER STRESS CONDITION

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INTRODUCTION

Water stress is a major problem in reducing agricultural productivity especially in dry and intermediate zones of Sri Lanka. Water deficits result from low and erratic rainfall and poor soil water storage, leading to the rate of water transpiration exceedings water uptake. Biotic and Abiotic stress can reduce average plant productivity by 65% to 87% depending on the crop (Mauad *et al.,* 2016). Abiotic stressors in plants are water stress, water logging, high and low temperature, ultraviolet radiation, heavy metals and salinity. Drought conditions are more common than flooding, which are usually created by the non-availability of water in the soil due to delayed or in frequent rains. Lack of rain, decrease water resources leads to reduced irrigation water availability increasing vegetable productivity. Water stress is causing qualitative and quantitative reduction of tomato yield. It effects on plant growth, photosynthesis, nuclear acids and proteins, nitrogen metabolism and carbohydrate metabolism. Drought during vegetative or early regenerative development as a rule decreases yield by decreasing the number of seeds, seed size and seed quality. Drought stress has non-critical impact on the quality and yield of tomato seed. Plant height, number of leaves and number of fruits per plant indicated huge outcomes toward water stress signifying water stress consequences for development. Silicon has beneficial effects on many crops, mainly under biotic and abiotic stress. Silicon assumes an essential part in plant tolerance to environmental stresses. Stress tolerance in plant has the capacity of environmental processes to remain normal. The effect of Silicon on the greater tolerance of higher plants to drought could be associated with an increase in the action of antioxidant defenses, reduction in the oxidative damage to functional molecules and membranes, and maintenance of many physiological as well as photosynthetic processes under water stress conditions (Mauad *et al.,* 2016). Silicon fertilization to increased crop growth, yield and quality in tropical soils and observed that the silicon application may be one of the available methods to increased crop growth and crop yield in arid or semi-arid areas. This study was conducted to investigate the effectiveness of Silicon in reducing the adverse effects of water stress and thereby increasing the quality of the yield in tomato (*Solanum lycopersicum*) variety Rajitha.

METHODOLOGY

Cultural Practices

A pot experiment was conducted for 6 months at a plant house located in Horticultural Crop Research and Development Institute (HORDI), Peradeniya. Plant house was equipped with a thermostat, and air circulation fans. The temperature was maintained at 28^0 C and relative humidity was measured daily with an RH meter. Recommended tomato seeds were obtained at vegetable division in Horticultural Crop Research and Development Institute (HORDI). Silicon was added as $MgSiO_3$ (Magnesium silicate). According to the treatment order, as shown in Table 1, magnesium silicate was added to the soil surface and mixed Water stressed plant root zone was covered using polyethylene.

Water management

Water stress was imposed by maintaining a moisture level equivalent to 50% of field capacity (FC), whereas the well-watered pots (control) were maintained at full field capacity (100%FC). Field capacity was measured by using two method core sampling method and volume basis method but in this experiment used in volume basis method values. Calculated field capacity and permanent wilting point moisture content were measured and measure plant available water for the water stress of 50% soil moisture deficit level. Plant received irrigation only when plant available water (PAW) is depleted by 50% in water stress plants (Dishani *et al* 2016). The water-deficit treatments were applied for 3-week age tomato plants. Every day maintained the water stress and plant water stress level using tensiometer. Water stress was imposed by maintaining a moisture level equivalent to 50% of FC, whereas the well-watered pots (control) were maintained at field capacity. Field capacity was measured on volume basis. Field capacity of soil is on volume basis was 35%. Permanent wilting point is 17.5% (multiply field capacity by 0.5). Calculated field capacity and permanent wilting point moisture content were measured and measure plant available water for the water stress of 50% soil moisture deficit level, plants received irrigation only when PAW is depleted by 50% in water stress plants (Dishani *et al* 2016).

35- [0.50x (35-17.5)] = 26.25

The water-deficit treatments were applied for 3-week age tomato plants. Monitored the soil water stress daily using a tensiometer.

Table 1: Treatments of the experiment

Treatments	**Composition**
T1	75 mg Si+ No water stress (WW 100%)
T2	75 mg Si + water stress (WS 50%)
T3	150 mg Si + No water stress (WW 100%)
T4	150 mg Si + water stress (WS 50%)
T5	No Si +No water stress (WW 100%)
T6	No Si+ water stress (WS 50%)

Experimental design

The experimental design was a Complete Randomized Design (CRD) with a factorial treatment structure. There were 6 treatments and 5 replicates. Stress and Silicon were taken as factors. The total population was 30 plants. Data were analyzed by analysis variance (ANOVA) and mean separation procedure by LSD using appropriate SAS procedures.

Quality parameters

Leaf relative water content

Leaf relative water content (LRWC) was measured (C. Kaya *et al.*, 2006) leaves per replicate was collected 2nd or 3rd leaf the main shoot then weighed to obtain fresh mass (FM). In order to determine the turgid mass (TM), whole leaves were floated in distilled water. During the imbibition period, leaf sample were weighed periodically after the water is gently wiped from the leaf surface with tissue paper. At the end of the imbibition period, leaf samples were placed in a preheated oven at 80 ^{0}C for 48 h to obtain dry mass (DM). All mass measurements were using an analytical balance with precision of 0.0001g. A value of FM, TM, and DM was used to calculate LRWC using the equation.

RWC (%) = [(FM – DM) / (TM – DM)] x 100

Total soluble solid and Firmness

Total soluble solid was measured using digital refractometer and result was expressed as Brix value (Gunawardena *et al.,* 2016). Tomato fruit firmness was determined on two fruit per replicate using hand penetrometer (Fruit pressure tester, model FT-327). Tomato fruit firmness (kgf) was measured at the equatorial surface for each individual tomato fruit (Caroline *et al.,* 2001).

Tomato fruit keeping quality

Fruit keeping quality (days) was determined when tomato fruits started showing signs of shriveling and decay. (Caroline *et al.*, 2001)

Seed weight and Seed germination

Tomato Seed were prepared for seed weight and germination. Seed were taken on two fruit per replicate and seeds were wash and air dry. Then Seed weight (g) measured by using balance and average seed weight was measured (Haghighi *et al.*, 2012). Seeds (30 seeds per replicate) were placed on one or more layers of moist tissue paper in Petri plates. These Petri plates were covered with lid and placed several days. Count the seeds germination using the equation (Haghighi *et al.,* 2012).

Percentage of germination = (Number of seed germinated / number of seed sown) x 100

RESULTS AND DISCUSSION

Leaf relative water content (LRWC)

Based on the result (Table 2), there was some difference of Leaf relative water content in treatment with no Si with water stress condition and this treatment is significantly different from all other treatments. The highest leaf relative water content was obtained in 150 mg silicon with well-watered plants treatment. no water stress 150 mg Si treatment plants (83.23%) and 75 mg Si no water stress treatment plants (83.04%) and also no Si no water stress treatment plants (82.1%). Lowest LRWC was observed when water stress no Si treatment plants (54.4%) and 75 mg Si water stress treatment plants (55.7%) and also 150mg Si water stress treatment plants (56.3%) because water stress decreases the plant growth and quality. Silicon can contribute to higher resistance of xylem vessels and that vessels structures are responsible for water transport within tomato plant. Silicon uptake plants with firmer xylem vessel walls can potentially avoid problems in these structures during water stress. In this experiment, magnesium silicate improves the LRWC in tomato plants than no silicon applied treatment, especially in water stress treatment. Results also agree with the findings of Shi et al (2016).

Total soluble solids (TSS)

Water stress increased total soluble solid (TSS) value in tomato fruits (Table 2). Highest TSS was obtained in plants with 150 mg Si in water stress conditions and the lowest TSS values were obtained in no silica and well-watered plants. It has been shown that reduced soil moisture increase sugar content in tomatoes (Caroline., 2011). But in this experiment magnesium silicate applied plants are higher TSS in both water stress and no water stress conditions. Application of silicon decrease in acidity and it may be due to an increase in the TSS because silicon is involved in the fast conversion of metabolites into sugar and their derivatives (Marodin., 2016).

Fruit diameter and fruit length

Based on the result (Table 2), there was a reduction in the fruit diameter and length in all water stress treatment plants. But silicon increases the fruit diameter and length under water stress conditions. The several changes in plant growth and developmental processes are often observed in plants that are slow water stress overtime because photosynthesis and transpiration are inhibited immediately after receiving the water stress and also water stress in the early growth period decreased the number of flowers leading to reduced number of fruits, and also fruit diameter and length. There was a significant difference in fruit diameter and fruit length between silicon applied and no silicon applied plants under water stress conditions. In this experiment, the result indicates magnesium silicate application increased the tomato fruit diameter and length under the water stress condition. Similar results were observed by Sibomana et al., (2013). water stress decreased fruit diameter and length compare to the no water stress treatment plant fruits, but the application of silicon increases fruit diameter and length in water stress treatments.

Table 2: Effect of treatments on quality parameters of Tomato.

Treatments	LRWC (%)	Fruit diameter (mm)	Fruit length (mm)	TSS	Firmness (kgf)	Fruit keeping quality	Seed weight (g)	Seed germination (%)
75mgSi/WW	83.04a	59ab	45ab	3.4c	4.72c	17bc	0.325ab	86.66a
75mgSi/WS	74.72a	49cd	41abc	4.3ab	5.94ab	16bc	0.279ab	66.66cd
150mgSi/WW	83.23a	60a	50a	4.6ab	5.34b	21a	0.406a	83.33ab
150mgSi/WS	77.3ab	51bcd	40bc	4.7a	6.3a	17bc	0.284ab	73.33bc
No Si/WW	82.1a	55abc	45ab	3.2c	4.3c	18b	0.279ab	76.66abc
No Si/WS	68.36c	44d	35c	4.2b	5.54a	15c	0.234b	56.66d

*WW: no water stress; WS: water stress. Means with the same letter(s) within a column are not significantly different at $P \leq 0.05$

Firmness and fruit keeping quality

Based on the result (Table 2), water stress resulted in increased firmness in fruits and also Silicon resulted in increased fruit firmness. Fruit firmness is mostly affected by the water content. Water stress conditions increased the fruit firmness agrees with the result indicated by Caroline (2011). In this experiment, the result showed that the application of magnesium silicate increased the tomato fruits' firmness in water stress treatments. Similar results were found by Weerahewa (2015). Also, magnesium silicate increased the fruit keeping quality. These result too agrees with Mohommad et al., (2018) and Islam et al., (2015). Fruit keeping quality in day was highest in 150 mg Si in well-watered plants and significantly different from all the other treatments. However, silica applied plants have higher keeping quality than no silica applied plants in water stress conditions, however these treatments were not significantly different from each other.

Seed weight and seed germination

Based on the result (Table 2), water stress conditions during vegetative or early regenerative development of plants decrease yield by decreasing the number of seeds, seed size and seed quality. In this experiment results (Table 2) indicate that the reduction in the seed weight in all water stress treatment plants but magnesium silicate increased the seed weight under water stress conditions. However, these treatments were not significantly different from each other. And also there was a reduction in the seed germination in all water stress treatment plants seeds but magnesium silicate increases the seed germination under water stress treatment plants seeds. However, these treatments were not significantly different to each other. Shi et al., (2016) showed that water stress negatively affects in seed germination.

CONCLUSION

Water stress negatively influences some quality parameters such as leaf relative water content, fruit diameter, fruit length, seed quality, fruit keeping quality, and seed germination. But the results showed that silicon application (150 mg Si) in water stress conditions has some positive effect on tomato fruit quality parameters. The findings of this experiment showed that the application of magnesium silicate has a positive influence on quality well as water stress tolerance effect on tomato var. Rajitha under water stress and also no water stress conditions.

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