EFFECT OF SILICON ON NUTRITIONAL QUALITY AND YIELD PARAMETERS OF TOMATO (*Solanum lycopersicum*) GROWN UNDER WATER STRESS CONDITION

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INTRODUCTION

Global agricultural production is threatened by rapidly changing unpredictable climate conditions. Water deficiency is the most vital factor involving agriculture in Sri Lanka. Temperature related extreme records have expanded over most areas in Sri Lanka. Yearly normal precipitation over Sri Lanka has been decrease throughout the previous 57 years at a rate of around 7 mm for each year (De Silva, 2006). Amid yala season the environmental change will huge effects on soil moisture shortfalls are increment and in this way irrigation need and water preservation is important in dry and intermediate zones in Sri Lanka (De Silva, 2006). In the whole plant, response to water stress involves different mechanisms, ranging from stomatal closure to root/shoot ratio increase, leaf area reduction, and osmotic adjustment. In the physiological mechanism of drought avoidance, maintenance of favorable water status in plants achieved through either efficient stomatal regulation or high root activity (Kaya *et al.,* 2006). Tomato in Sri Lanka is much lower than the world normal as the regular climate changes unfavorably influence normal production (Dishani, 2016). Silicon (Si) is the second most abundant element in the earth' crust after oxygen (Shi et al., 2016). Silicon most commonly found in lithosphere in form of solution as silicic acid and all plant uptake directly as silicic acid (Ma et al., 2001). Si assumes essential part in plant tolerance to environment stresses. There is two type of resistance; (i) Stress avoidance-In the whole growth process does not meet with the face of adversity and (ii) Stress Tolerance-Plant has a capacity of environmental processes remain normal. The effect of Si 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). This study was conducted to investigate the effectiveness of Si in reducing the adverse effects of water stress and thereby increasing the nutritional quality and yield in tomato.

METHODOLOGY

Treatments of the experiment were 75 mg Si and no water stress (T1), 75 mg Si and water stress 50% (T2), 150 mg Si and no water stress (T3), 150 mg Si and water stress 50% (T4), no Si and No water stress (T5), no Si and water stress 50% (T6). A pot experiment was conducted for a period of 6 months at a plant house located in Horticultural crop research and development Institute (HORDI), Peradeniya, Central Province, Sri Lanka. Plant house was maintained temperature at 28 ^{0}C with thermostat and air circulation fans. Relative humidity was measured daily with Rh meter. Recommended tomato seeds var. (Rajitha) were obtained from vegetable division in HORDI. Silicon was added as MgSiO3 (Magnesium silicate). According to the treatments order magnesium silicate was added to soil surface and mixed. The water stress plant root zone was covered using transparent polyethylene sheet. Continue fertilizing tomato plants about every 3-4 weeks. Water stress was imposed by maintaining a moisture level equivalent to 50% of FC, whereas the well-watered pots (control) were maintained at full field capacity (100% FC). 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 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 maintain the water stress plant water stress level using tensiometer. The experimental design was a Complete Randomized Design (CRD) with factorial treatment structure. There are 6 treatments and 5 replicates. Stress and Silicon were taken as factors. Total population is 30 plants. Data analyzed by analysis variance (ANOVA) and mean separation procedure by LSD using appropriate SAS procedures.

RESULTS AND DISCUSSION

Nutritional parameters

Phosphorus and Potassium analysis of fruits

Figure 1 and figure 2 indicated that the water stress reduces the Phosphorus and Potassium by tomato plants. Lower potassium level observed in water stress treatments but water stress 75mg Si treatment plant fruits (0.5ppm) and water stress 150mg Si treatment plant fruits (0.7ppm) were have better potassium level than water stress no Si treatment plant fruits (0.433ppm). Lower phosphorus level observed in water stress treatments but 75mg Si water stress treatment plants (0.735%) and water stress 150mg Si treatment plants (1.429%) were have higher phosphorus level than water stress no Si treatment (0.49%). However, application of magnesium silicate improves the nutrient uptake by plant. Similar results found by Sahebi (2015) and indicated that silicon is one of the most prevalent macro elements, performing an essential function in healing plants in response to environmental stresses. Silicon minimizes toxicity of elements and increases the availability of P, and enhances water stress along with tolerance in plants through the formation of silicified tissues in plants. Similar result found by Satisha (2017) nutrient contents were partitioned into leaves, shoot, roots and fruits and result showed that the uptake of potassium substantially higher in plants with silicon. Liang (1999) also found that the K plays an essential role in processes involving osmotic adjustment and its adequate level in plants may improve water stress tolerance under water stress conditions, silicon may result in better supply of potassium.

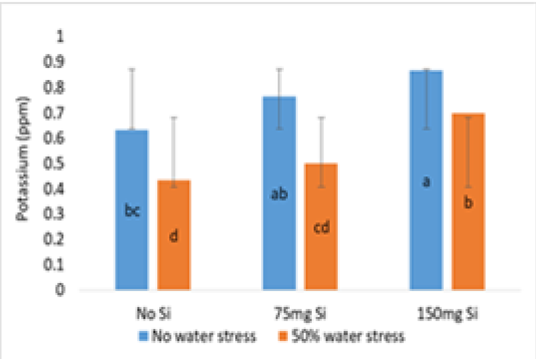

Figure 1: Effect of treatment on potassium level of plants

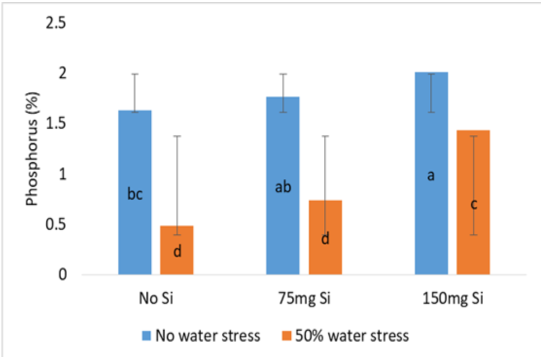

Figure 2: Effect of treatment on phosphorus level of plants

Calcium and Magnesium analysis of fruits

Based on the results Figure 3 indicated that the highest Calcium level observed in no water stress 75 mg Si treatment plants (4.460ppm) and no water stress 150 mg Si treatment plants (5.252ppm) and no water stress no Si treatment (3.969ppm). Lower Calcium level observed in water stress treatments but 75 mg Si water stress treatment plants (3.428ppm) and water stress 150 mg Si treatment plants (4.195ppm) were have higher Calcium level than water stress no Si treatment (2.88ppm). Figure 4 indicated that the highest Magnesium level were observed in no water stress 150 mg Si treatment plant fruits (3.192ppm) and no water stress 75 mg Si treatment plant fruits (2.714ppm) and also no water stress no Si treatment plants fruits (2.396ppm). Lower Magnesium level were observed in water stress treatments but water stress 75 mg Si treatment plant fruits (2.336ppm) and water stress 150 mg Si treatment plant fruits (2.511ppm) were have higher Magnesium level than water stress no Si treatment plant fruits (2.32ppm). Pulz (2008) found same results that calcium and magnesium silicate fertilization increased water stressed potato phosphorus content. Similar result found by Das, (2017), showed that the presence of silicon also been reported to affect the absorption and translocation of several macro and micro nutrients and also he observed silicon is accumulated in plants to total concentrations in dry matter similar to those of essential macro-nutrients such as Potassium, Calcium, Magnesium, Sulphur and Phosphorous. Similar results found by Das (2017) and he indicated that the presence of silicon also been reported to affect the absorption and translocation of several macro and micro nutrients and also he reported silicon is accumulated in plants to total concentrations in dry matter similar to those of essential macro-nutrients such as magnesium. Gunes (2008) also found that the application of Si under water stress significantly improved magnesium uptake by plants.

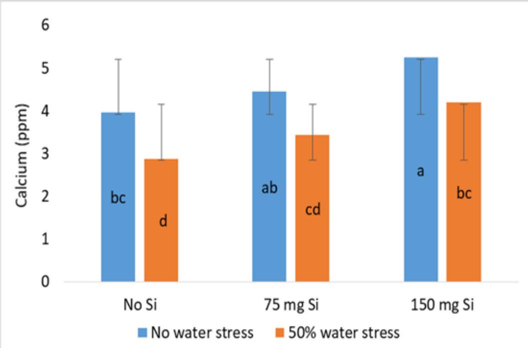

Figure 3: Effect of treatment on Calcium level of plants

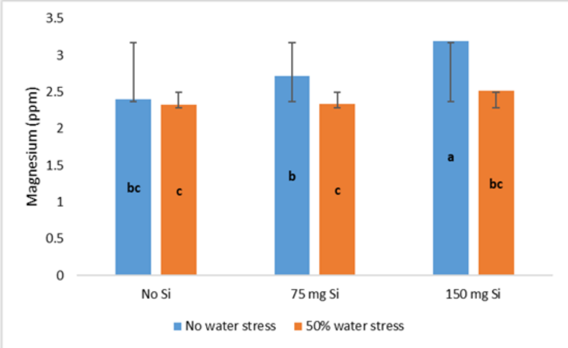

Figure 4: Effect of treatment on Magnesium level of plants

Yield Para meters

Number of flowers per plant

The highest number of flowers was observed in the treatments of 150 mg Si in well-watered tomato plants and the lowest number of flowers was observed in no Si and water stressed tomato plants (Table 1). Water stress are badly effect of flowers formation and increases the flower abortion (Olaniyi, 2010). Water stress decreasing the tomato fruits settings and it also effect the low quality tomato fruit yield obtained for tomato plants might be due to non-development of flowers. This experiment results showed application of magnesium silicate in water stress treatment it helps to increase the flower formed than no Silicon applied water stress treatment plants.

Number of fruit per plant

The treatment of 150 mg Si with no water stress has shown the highest number of fruit per plant and the treatment with no Si and water stress has shown the lowest number of fruit per plant. When compared the water stress treatments 75 mg Si applied water stress plants and 150 mg Si applied water stress plant have shown higher number of fruits than the treatment with no Si applied and water stress treatment. However, these treatments of Si applied and no Si applied are not significantly different. Jarosz (2014) indicate that silicon is the only element that does not harm plants when taken up in higher amount and its use in plant fertilization improves the plant growth and yield. Silicon application helped in improving fruit set and minimizing fruit drop of tomato same result found by Dattatray (2018).

Fruit Weight

The treatment of 150 mg Si and no water stress has shown the highest fruit weight. However, it is not significantly different from the treatment of 75 mg Si and no water stress and treatment of no Si and no water stress. The treatment with no Si and water stress has shown the lowest fruit weight however it is significantly different from 150 mg Si with water stress treatment which has shown the highest fruit weight among the water stress treatments (Table 1). However, the treatment with no Si and water stress is not significantly different from the treatment of 75 mg Si and no water stress. These experiment results (Table 1) indicate that the application of 150 mg Si of magnesium silicate has positive effect of tomato fruit weight under water stress conditions. Fruit weight is affected by water stress condition due to the reduced amount of water uptake from tomato plants Dattatray (2018).

Fruit Yield

The treatment of 150 mg Si and no water stress has shown the highest fruit yield (1.4 kg) which is significantly different from no water stress treatment. The treatment with no Si and water stress has shown the lowest fruit yield (0.7 kg) and it was significantly different from treatments with 75 mg Si and 150 mg Si with water stress. All the treatments with Si have shown higher fruit yield in both no water stress and water stress treatments. Therefore, application of magnesium silicate has increase the fruit yield in Tomato variety Rajitha in this experiment in water stress conditions. This experiment results agree with that findings of Meena (2014) as the application on silicon fertilization has increased crop yield in tropical soils and also observed that the silicon application may be one of the available resource for increased crop growth and crop yield in arid or semi-arid areas.

Table 1: Effect of treatments on yield parameters of Tomato.

Treatments	**Flowering (11WAP)**	**Number of fruit per plant**	**Fruit weight (g)**	**Fruit yield (kg)**
75mgSi/WW	21.6ab	16.4ab	66.1a	1.173a
75mgSi/WS	15.6bc	10.8c	55.7b	0.77bc
150mgSi/WW	26.4a	19.6a	68.8a	1.4a
150mgSi/WS	19.2abc	13.6bc	56.3a	0.967abc
No Si/WW	21abc	16.6a	66.3a	1.146ab
No Si/WS	13abc	12c	54.4b	0.707c

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

Table 2: Analysis of variance of silicon and water stress on yield parameters of Tomato

Source of variations	**df**	**MS**			
		Flowering (11WAP)	**Number of fruit per plant**	**Fruit weight(g)**	**Fruit yield(kg)**
S (Si trt)	2	89.733	26.533	13.108	0.188
W(water stress trt)	1	374.533**	202.8**	1009.2**	1.354**
S*W	2	2.533	2.8	2.925	0.0009
Error	24	38.183	8.6	33.644	0.099

*indicates significant at the $0.01 \leq P < 0.005$ probability level, and **indicates significant at the ≤ 0.01 probability level.

CONCLUSION

Water stress negatively affects the nutrient level in tomato fruits. The findings of this experiment showed that the application of magnesium silicate have a positive influence on some nutrients uptake as well as water tolerance effect on tomato var. Rajitha under the water stress and also no water stress conditions.

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