OPENING MINDS: RESEARCH FOR SUSTAINABLE DEVELOPMENT

Preliminary Study on Impact of Induced Temperature and Water Stress on Yield Parameters of Tissue Cultured *Ananas comosus* (Pineapple) – Variety Kew

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1 INTRODUCTION

Growth and development of plants are affected by increase in temperature and decrease in rain fall due to temperature and water stress imposed on them (Hatfield *et al.*, 2015). These stresses would have an impact on the growth and yield of the crop plants. Rosen-zweig and Hillel, (1995) have reported that when the temperature exceeds the optimum that is required for biological processes, the plants respond negatively showing a sharp decline in growth and yield. Dishani and De Silva, (2013) and Gunawardana *et al.* (2011) have reported that temperature plays a main role in growth and development of tomato plants. It is further reported by Gunawardana *et al.*, (2011) that fruit setting of tomato was minimum under the temperature stress due to pollen sterility. In okra, quality of fruits was poor and pods mature quickly at high temperatures. The same authors have reported that there has been a reduction in yield of chilli and if the plant is not under water stress this reduction could be managed.

Pineapple is a tropical plant and grows best in a moderately warm climate (16° to 33°C). For optimum growth pineapple need at least 50mm rainfall per month. Pineapple cannot tolerate frost and temperature above 40°C. This plant has developed a specialised metabolic system (CAM) for capturing carbon dioxide at night for use during the day. This mechanism greatly reduces water loss which is an adaptation to drought from its epiphytic ancestry (epiphytes grow above the ground on other plants for support). (Sideris and Krauss, 1955) Low number of stomata and the leaf shape and texture allow, to a certain extent for drought condition (Krauss, 1949).

Pineapple is a popular fruit among people in Sri Lanka as well as in the world. It is the third most important fruit in the world, after banana and citrus (Bartholmew *et al.*, 2015). This fruit is used as a dessert and syrup is canned and exported. The residue is used as cattle feed and fertilizer. The fibre of the leaves is used in weaving textiles.

In vitro propagation of *Ananas comosus* (L.) Merr is not a novel technique to Sri Lanka (Fernando, 1984). *In vitro* propagated pineapple is very popular among farmers due to the beneficial characteristics such as early fruiting and high yield. The variety Kew offers a better value for commercial purposes compared to the type Mauritius when cultivated in Sri Lanka, for processing and fresh fruit market (Gamage *et al.,* 1995).

Since there is a high demand for the *in vitro* propagated pineapple plants, especially variety Kew, among farmers in Sri Lanka, this paper intends to determine how the predicted temperature and water stress due to climate change would have an impact on the vegetative growth and yield parameters of *A. comosus*. The yield parameters measured are time duration from fruit initiation to harvesting, weight and length of fruit with and without crown, diameter of the fruit, firmness of the peel and the flesh, total soluble solids and the pH of the fruit juice.

2 METHODOLOGY

The study was carried out in the premises of the Open University of Sri Lanka in two locations in a poly-tunnel type plant house where the maximum day temperature was set to 35 °C, and in a plant house where the ambient temperature was maintained, from June 2015 to May 2017. *In vitro* propagated pineapple plants were planted, one plant each, in pots having the diameter of 0.5 m, in a potted medium of coir dust, top soil and compost in 1:1:1 ratio. These divided into four sets each having three replicates. Two sets were maintained under ambient temperature in the plant house, and the other two sets at maximum of high temperature (35°C) in the poly-tunnel. Of the two sets of plants in the poly tunnel one set was watered daily, to the field capacity and the other set to half of field capacity soil moisture. The plants in the plant house were also treated similarly. Plants were manured according to the recommendations of the CIC seed farm Pelwehera, Dambulla. Four treatments used in this study are as follows:

T1-35°C inside the Poly Tunnel (TS) with watered to field capacity (NWS)

T2-35°C inside the Poly Tunnel (TS) with watered to 50% field capacity (WS)
T3-32°C Ambient Temperature (NTS) without water stress as moisture at field capacity (NWS) (Control)

T4-32°C Ambient Temperature (NTS) with water stress as moisture at 50% field capacity (WS)

The plants were maintained in completely randomized design. The dates of fruit set and harvesting were recorded.

The ripe fruits were picked and their weights and lengths with and without the crown were recorded. The diameter at the maximum point was measured using a venier calliper. Firmness of peel and flesh was measured by penetrometer.

After extracting the juice, the pH was measured using a pH Consort C830. The total soluble solids were also measured with digital refractometer Digit-032 at 20°C respectively. Total soluble solids were reported as degrees Brix (Salome, Laurent, Pierrre, Patrice, Hilaire, 2011).

An analysis of variance (ANOVA) of the result was performed using the statistical program Minitab (version 14, Minitab Inc.).

3 RESULTS AND DISCUSSION

3.1 Time taken for harvesting from fruit set

Time taken to harvest from the day of fruit set is shown in Figure 1. According to the results the time taken for the fruit to harvest from the day of fruit initiation was only 73 days when the plants are not under water or temperature stress, indicating that the temperature and the water stress have a negative impact on the fruit growth and ripening. This treatment (T3) is significantly different from other treatments. The plants were exposed to either temperature and water stress or both stresses made longer period to mature.

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Highest duration was 98 days in plants grown under 35°C high temperature stress with no water stress condition (T1). Although pineapple has many very efficient moisture conserving systems and has one of the highest water use efficiencies among cultivated crops and can survive severe drought, they still benefit from "good" rainfall/irrigation. Under moisture stress plant growth and yields are significantly reduced. During extended dry periods the plant 'closes down' and crop schedules are upset (**Salomé** *et al.* 2011).

3.2 Fruit diameter

Figure 2 indicates that the diameter of the fruit is maximum when the plants are under water stress and temperature stress. However the diameter of the fruit was lowest in no temperature and no water stress which is significantly different from other treatments. High diameter observed with pineapple fruits seems to indicate a gain of flesh. It would mean that fruits contain more juice, when fruits were grown under temperature and/ or water stresses. However, this disagrees with the results of Black, (1962).

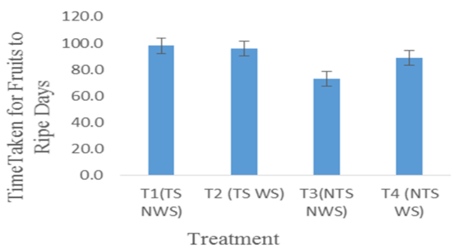

Figure 1: Time taken to harvest from the fruit set

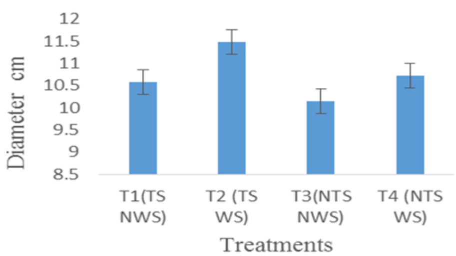

Figure 2: Effect of Temperature and Water Stress on Fruit Diameter

3.3 Firmness of flesh

According to Figure 3, the lowest firmness of flesh of the fruits was obtained in treatment 2 (T2) indicating that fruit is soft when the plant is under temperature and water stress. When firmness of flesh is low or when fruit is soft, it is preferred over the hard flesh fruits. Firmness of fruit is determined by the cell wall structure and cuticle properties (Chaib *et al.* 2007). When the fruit is ripening there is cell wall degradation and remodeling of cell wall which causes softening of the flesh of the fruits. (Matas *et al.* 2009).

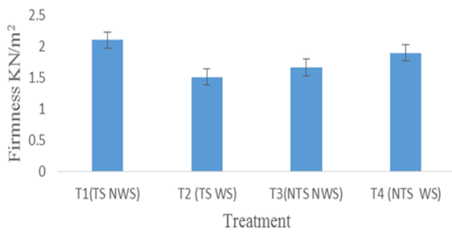

Figure 3: Impact of Temperature and Water Stress on Firmness of Flesh

3.4 Total Soluble Solids

Figure 4 shows the total soluble solids in the fruit. The total soluble solid is an indication of the amount of sugars present in the fruit. Significantly highest total soluble solid was obtained in fruits grown under no temperature and no water stress (Treatment 3). This value is the highest among the fruits, when the plant is not under stress, indicating that the plant produce fruits which are more palatable if the plant is not under stress. However May (1993) has observed that low water stress resulted in products with best soluble solids in tomatoes. High water stress has resulted in, high soluble solids.

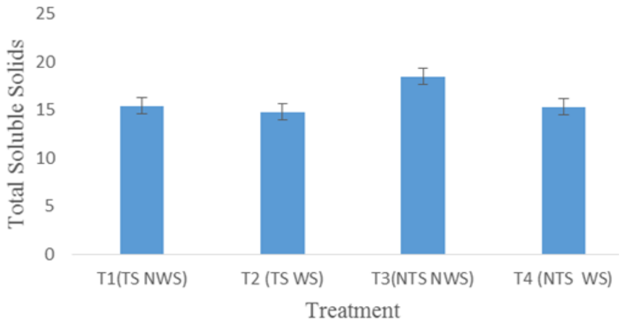

Figure 4: Effect of Temperature and Water Stress on Total Soluble Solids of Fruit

The pH of these fruits ranged from 3.1 to 4.53. Lowest pH was observed in T3. Microorganism has a minimal and an optimal pH required for its growth.

The excellent storing qualities of fruits are related to their respective pH, such as fruits with low pH value are usually not really spoiled by bacteria.

Table 1: pH of juice of Pineapple fruits under different Treatments

Treatment	T1	T1	T1	T2	T2	T2	T3	T3	T3	T4	T4	T4
pH	4.23	4.3	4.53	3.99	3.92	3.96	3.1	3.2	3.1	3.71	3.8	3.82

4 CONCLUSIONS

Plants grown under no temperature and no water stress (T3) took less time for fruit set and maturation. Further significant results were obtained in total soluble solids in no temperature and no water tress treatment (T3). Thus, it is observed that the temperature and water stress has a negative impact on some quality parameters of pineapple fruits. However, further investigations are required to confirm the results.

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