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GROWTH, PHYSIOLOGY AND FRUIT QUALITY OF *HIBISCUS SABDARIFFA* L. IN RESPONSE TO REGULATED DEFICIT IRRIGATION

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Abstract

The effects of deficit irrigation technique on growth and fruit quality of roselle (*Hibiscus sabdariffa* L.) was observed. The result shows that minimum weight of the yield was obtained from treatment grown with well watered (WW) condition. Plant height was affected by reduction of water application. Regulated deficit irrigation (RDI) tended to decrease all means of growth parameter except stem fresh and dry weight. RDI shows significant effect on yields, where the reduction of 50% water produce more fruits compared to control plants. The impact of RDI was not significant effect on physiological change of roselle. Thus, RDI could be a feasible technique for Roselle production as it saves large amounts of water with reduction on plant growth but increase the yield as compared to well watered (WW) of roselle.

Introduction

Hibiscus sabdariffa L. of Malvaceae has a wide number of uses in food and as additive to foods worldwide and particularly in Malaysian (Mohd-Esa *et al*. 2010). Cultivation of roselle requires irrigation, but water limitation is one of the problems. For developing practical solutions to manipulate physiological response to water stress is regulated deficit irrigation (RDI). These techniques can decrease the water use (McCarthy 2002).

In RDI technique, crops are allowed to sustain some degree of water deficit in order to reduce the cost and potentially increase income by reducing the cost of water (Owusu *et al.* 2011). Campos *et al.* (2009) determined partial root drying (PRD) effects to *Solanum lycopersicum* L. which successfully maintained the yield compared to conventional irrigation of tomato.

It was, therefore hypothesized that the application of RDI may play a role in retarding plant growth, reducing physiological activity and improving fruit quality of roselle. The present work was undertaken to determine the effects of RDI on physiological change, growth and fruit quality of *Hibiscus sabdariffa* L.

Materials and Methods

The study was conducted at Field 10, Universiti Putra Malaysia. The seeds were germinated on germination tray containing peat moss as substrate. After 10 - 15 days of sowing, the seedlings were transferred 25.4 × 30.48 cm polybag. The soil mixture of planting medium was prepared by mixing top soil, coco peat and paddy husk at a ratio of 2 : 1 : 1. The polybags were placed under shade-house. Distance between plants was 1 m × 1 m. The experiment was laid down in randomized complete block design having three replications. The experiment was two factorial with irrigation (Well watered; WW and regulated deficit irrigation) and time of sampling (2, 4, 6,

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8, 10 and 12 weeks after irrigation). For control treatment, seedlings were well watered (WW). RDI plants received half amount of water as was used by plants in the WW.

Plant height of *H. sabdariffa* was measured from shoot tip to root tip. This parameter was recorded at every two weeks interval until week 12. Total leaf area was determined with the help of a leaf area meter (Model LI-3100C, USA). The samples were washed thoroughly to remove the planting medium attached to the sample. Fresh weight of leaves, stem and root were determined by using digital scale. Afterward, the clean samples were kept an oven at 50°C for five days. Then weights of dried samples were determined.

The rate of photosynthesis, respiration and transpiration and the conductance of stomata were measured monthly with the help of a portable meter (Model LICOR, LI-6400, USA). These parameters were measured using fully expanded leaves sampled from the third or fourth nodes from the apex of the main stem or younger plageotropic branches at commercial harvest stage and counted and later on measured by using a digital balance. During harvesting, the ambient temperature was 20 ± 1°C) with 65% of relative humidity. The parameter such as soluble solid concentration (SSC), titrable acidity (TA) and pH were determined only at the end of harvest.

Ten gm of calyx and 40 ml of distilled water were macerated and homogenised by a blender. The mixture was filtered using cotton wool and the drops of the filtrate were placed on the prism glass of refractometer to obtain the percentage of SSC. The pH of the juice was measured using a glass electrode pH meter (Grison Micro pH 2000). The data were subjected to ANOVA using SAS and LSD was also calculated following a significant t-test. The relationships between parameters were calculated using Pearson correlations (SAS 2004).

Results and Discussion

Fig. 1 shows the effects of WW and RDI on the height of roselle. Water deficit was resulted a reduction in plant height of roselle. Similar findings were reported by Ogbonnaya *et al.* (1998) when kenaf was grown on a loose-textured sandy soil in the greenhouse and exposed by water deficit treatment.

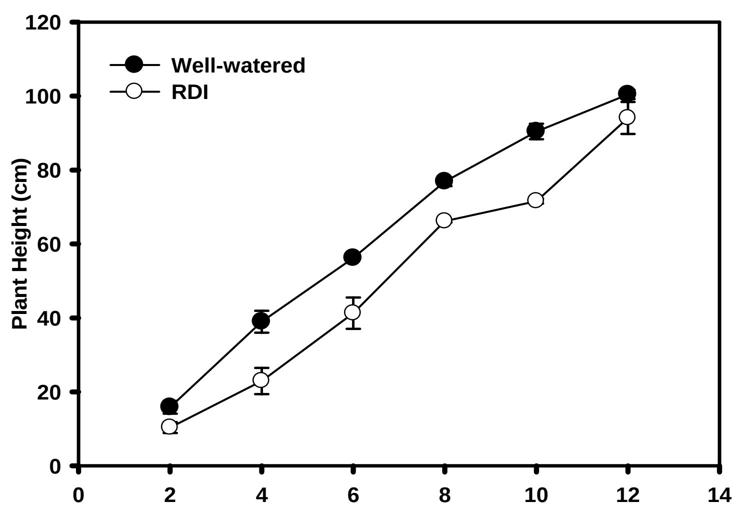

Fig. 1. Plant height of roselle as influenced by WW and RDI treatment. Vertical bar represents standard error.

Total leaf area was significantly different between WW and RDI treatment for week 2, 4, 8 and 12 after treatment (Fig. 2). The total leaf area of roselle plants was significantly affected by RDI. Similar results were reported for kenaf, tomato and avocado (Ogbonnaya *et al.* 1998, Chartzoulakisa *et al.* 2002).

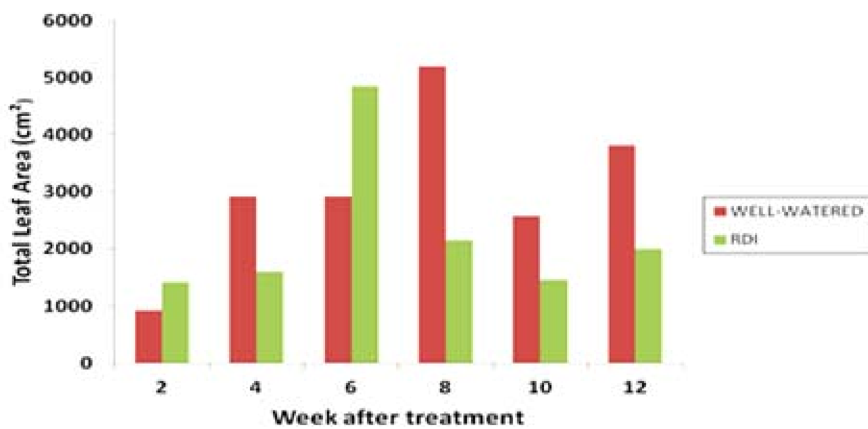

Fig. 2. Total leaf area of roselle as influenced by WW and RDI treatment.

The dry weight of leaf and root increased in both the treatments throughout the experiment period (Figs 3, 4). WW plants showed higher leaf and root dry weight as compared to RDI treatment. The difference between both treatments did not show any significant result different for stem dry weight (Fig. 5).

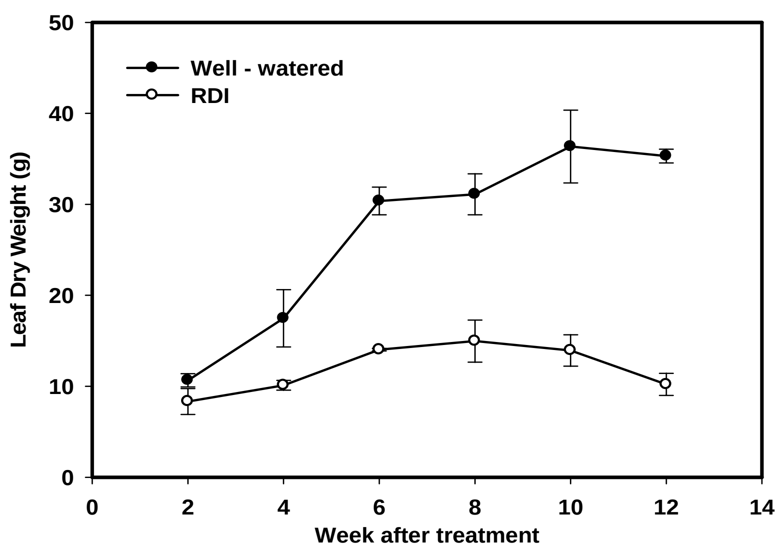

Fig. 3. Leaf dry weight of roselle as influenced by WW and RDI treatments. Vertical bar represents standard error.

Similar to avocado and *Capsicum anuum* L., RDI treated roselle showed reduced dry weight of leaf, root and stem (Chartzoulakisa *et al*. 2002). In contrast, both vegetative dry mass and its distribution among plant organs (roots, leaves and fruits) of hot pepper were similar for WI and RDI treatment, but slightly higher than WW treatment (Delfine *et al.* 2001).

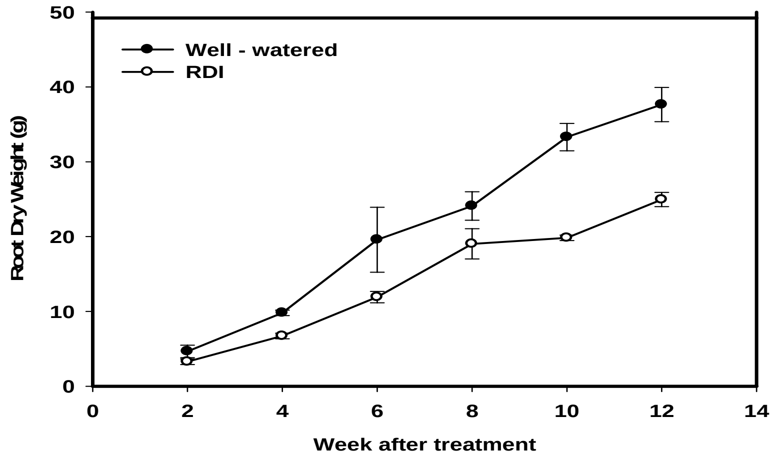

Fig. 4. Root dry weight of roselle as influenced by WW and RDI treatments. Vertical bar represents standard error.

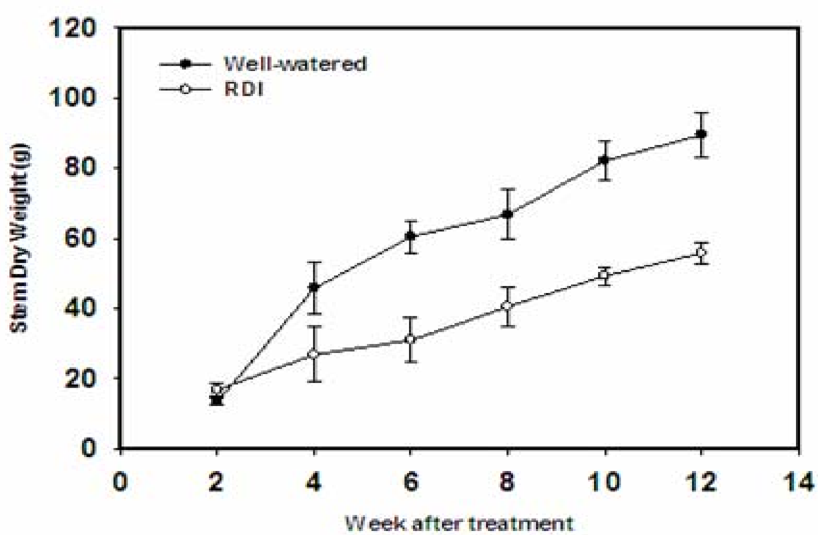

Fig. 5. Stem dry weight of roselle as influenced by WW and RDI treatments. Vertical bar represents standard error.

The trend of photosynthetic rate flux was inconsistent for first three months of the experimental period (Fig. 6). There was no significant difference between WW and RDI treatments. However, previous study showed that deficit irrigation declined the photosynthesis rate of avocado (Chartzoulakisa *et al.* 2002).

Stomatal conductance for RDI treatment decreased throughout the study period and the values were lower than WW treatment (Fig. 7). However, the effect of WW and RDI treatments did not show any significant difference on stomatal conductance on 1st, 2nd and 3rd months after treatment (Fig. 7).

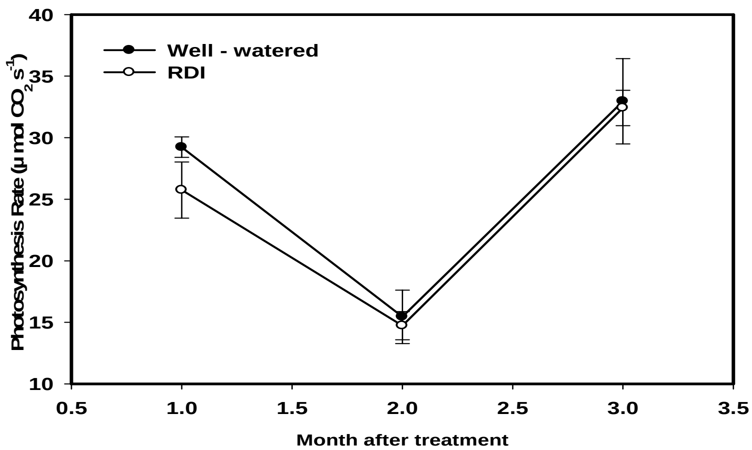

Fig. 6. Photosynthesis rate of roselle as influenced by WW and RDI treatments. Vertical bar represents standard error.

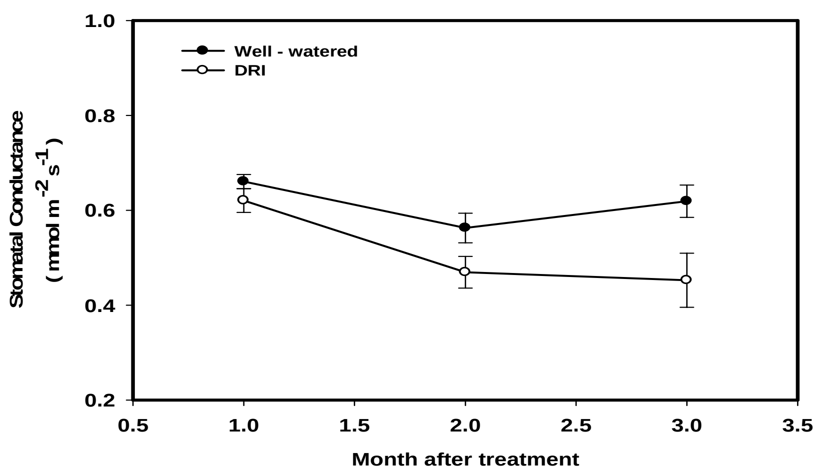

Fig. 7. Stomatal conductance of roselle as influenced by WW and RDI treatments. Vertical bar represents standard error.

Stomatal conductance (Fig. 7) was always higher in WW than RDI treatments, and its value for RDI was reduced from month 1 to month 3. Stomata may sometimes respond to soil water depletion in advance of or without a measurable change in leaf water status (Saliendra *et al*. 1995), as the case with RDI and WW treatments on the some measurement occasions in the present study. Such a somital response has been associated with chemical signals, particularly ABA, produced by roots in drying soil and transported to leaves in the transpiration stream (Davies *et al*.

2002). The decrease in stomatal conductance was in agreement with the finding of Ogbonnaya *et al*. (1998).

Plants in RDI treatment exhibited a reduction for transpiration rate parameter (Fig. 8). No significant difference was observed between WW and RDI regarding the changes of transpiration rate three months of the study period. However, transpiration rate decreased slightly at the second month (Fig. 8). According to Ogbonnaya *et al.* (1998), a high rate of stomatal conductance and transpiration occurred when soil water was available but leaf conductance and transpiration rate markedly reduced when water was limited.

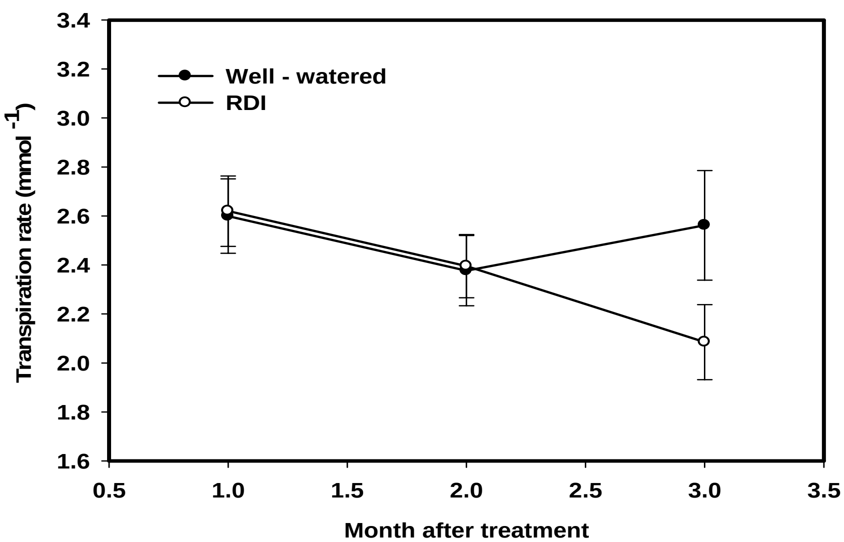

Fig. 8. Transpiration rate of roselle as influenced by WW and RDI treatments. Vertical bar represents standard error.

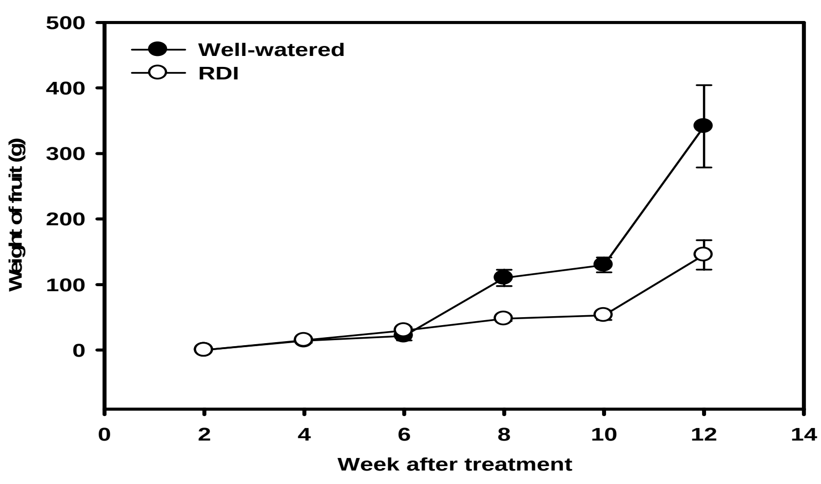

Fig. 9. Weight of yield of roselle as influenced by WW and RDI treatments. Vertical bar represents standard error.

Cline *et al*. (1985) obtained the highest yields from highest regulated irrigation regime and lowest yield from the lowest irrigation. Davenport (1994) also stated that water stress affect yield and quality of vegetables, but not weight.

ANOVA showed that there were significant differences between WW and RDI treatment. Weights of fruits showed higher in WW than RDI (Fig. 9). This result indicate that WW treatment had enough and sufficient water for optimum growth and yield as compared to RDI. Yield correlated with plant height and number of fruit for WW and RDI treatments. A reduction in the fresh fruit yield of roselle due to deficit irrigation for reduced the fruit size and the total fruit weight. This result is in agreement with the findings of Owusu *et al.* (2011) on okra grown under rain shelter, where the full irrigation resulted in higher fruit yields compared to RDI treatment.

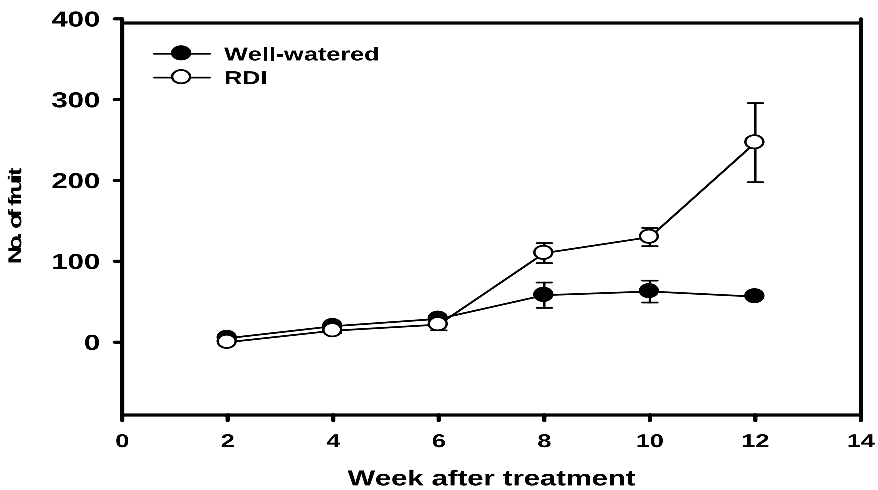

Fig. 10. Number of fruits of roselle as influenced by WW and RDI treatments. Vertical bar represents standard error.

Well watered (WW) treatment resulted significantly low number of fruits as compared to RDI (Fig. 10). The number of fruits was lower than WW in RDI treatment at the beginning of experiment but increased thereafter and higher than WW treatment started at week 6. Increase in number of fruits of RDI treatment is probably due to the translocation between source and sink. This was because the result showed that RDI treatment reduced plant growth parameters such as, plant height and fresh and dry of partitioning. However, this result is contradicted with Lucio *et al.* (1996), who reported that deficit irrigation reduced the number of tomato fruit.

The fruit quality (pH value, TSS and TA content) of roselle influenced by WW and RDI treatment after three months of experiment period. pH value of roselle was significantly affected by different amount of water application (Fig. 11). RDI plants had significantly higher pH values than WW plants. Similar result was reported for *Citrus sinensis,* where pH value was increased significantly in reduced water irrigation (Walid *et al.* 2012). In contrast, McCarthy *et al.* (2002) reported that pH value was similar for RDI and WW treatment in grape vines.

On the other hand, WW and RDI treatments had no significant effect on SSC and TA content, although the WW treatment had slightly higher values for these parameters (Fig. 11). Similar results were reported by Perez-Sarmiento *et al*. (2010) who found equal TA for WW and RDI treatment in apricot crops and citrus plants, respectively.

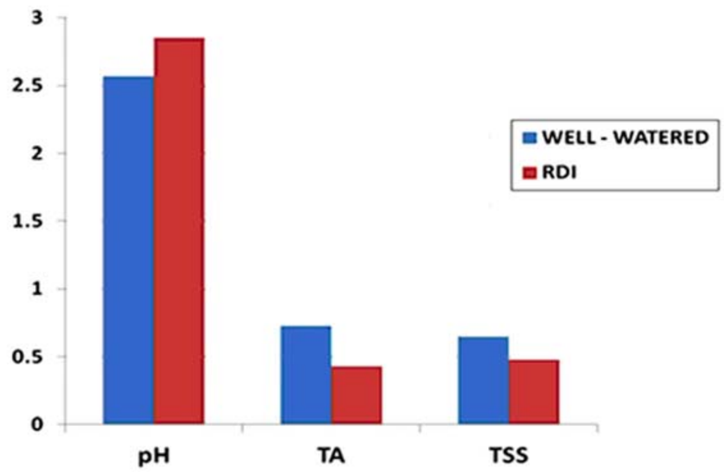

Fig. 11. pH, TA and TSS of roselle influenced by WW and RDI treatments.

From the experimental result one can conclude that regulated deficit irrigation could be a feasible technique for roselle production, because it saved large amount of irrigation and also increased the yield as compared to well watered treatment.

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