International Journal of Minor Fruits, Medicinal and Aromatic Plants. Vol. 6 (1) : 30- 37, June 2020

Morpho-physiological and yield characteristics of interspecific hybrids between cultivated eggplant (*Solanum melongena* L.) and wild relatives in response to drought stress

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Received : 02.12.2019 ; Revised : 22.03.2020 ; Accepted : 25.03.2020

ABSTRACT

Drought has been identified as one of the principal global problems, which further exacerbates under climate change. Wild relatives of crops are a genetic resource with an array of traits of interest, including tolerance to biotic and abiotic stresses. The aim of this study was to evaluate the drought tolerance ability of ten interspecific hybrids between seven different cultivated varieties of Solanum melongena L. and three wild relatives (Solanum insanum, Solanum incanum and Solanum lichtensteinii). The Experiment was conducted in a protected house at the University Research Station, Meewatrura, Peradeniya (WM2b) during Maha 2018. The experimental materials were subjected to three irrigation treatments viz: field capacity (control, I1) and two droughts stress levels (70% and 40% of field capacity: I2 and I3, respectively). Plant morphological characters, physiological characters and yield attributes were measured. Results revealed that drought stress (I2 and I3 treatments) significantly (pd 0.05) reduced the plant height, canopy width, number of leaves, number of branches, number of fruits and finally the average yield of all interspecific hybrids. The proline content and chlorophyll concentrations (a, b and total) were significantly increased (pd 0.05) in the plants under the drought stress. Relative water content also significantly increased (pd 0.05) for I3 level. Total soluble solids of fruits were increased significantly (pd 0.05) due to the drought stress. Moreover, interspecific hybrids MEL2 × S. insanum, MEL3 × S. insanum, MEL5 × S. insanum, MEL6 × S. insanum and MEL7 × S. insanum, have shown better performance under I1 and I2 treatments while, MEL2 × S. insanum, MEL3 × S. insanum, MEL5 × S. insanum, MEL6 × S. insanum, MEL7 × S. insanum showed best tolerance under I3 treatment. Thus, those interspecific hybrids have potential to utilize as genetic materials for future breeding programs to develop drought resistant eggplant varieties.

***Keywords* :** Drought stress, Eggplant, Interspecific hybrids, *Solanum incanum*, *S. insanum*, *S. lichtensteinii*, *S. melongena*

INTRODUCTION

In many regions of the world, there have been considerable changes in the nature of droughts, floods and extreme temperature events since the middle of the twentieth century. Now onwards at least 0.2 °C per decade average increment of temperature is projected (Liu *et al.*, 2019). Annual average rainfall of Sri Lanka has been decreasing for the last 57 years at a rate of about 7 mm per year. Agricultural crops are affected by global warming due to increment of atmospheric CO_2 concentration and changing of climatic conditions (De Costa, 2008). Global warming results in erratic climate change and the reduced groundwater availability because of competition the use of ground water for industrial needs (Green *et al.*, 2011). Increase the crop production selection of new genotypes having resistant to abiotic stresses such as water deficit, salinity, extreme temperatures is essential (Ashraf *et al.*, 2009). Domestication process cause to severe reduction in genetic diversity of most crops when comparing with their wild relatives (Smýka *et al*., 2018). Wild relatives of crops inherent largely untapped genetic diversity (Momin *et al*., 2016) for biotic and abiotic stress resistance, and could greatly expand the available domesticated gene pools to assist crops to survive in the predicted extremes of climate change. Genomic strategies can obtain in the introgression of these valuable characteristics into the domesticated crop gene pools, it is key issue for evaluated for crop improvement (Zhang *et al.*, 2017). Eggplant takes over a half an year developing time under warm climatic conditions to give preferred high quality fruits and it can be classified as a moderately sensitive vegetable crop for drought (Ghaemi and Rafiee, 2016). To develop crops having tolerance to drought it is necessary to identify genetic variability for drought among crop varieties, or among sexually compatible species to incorporate drought-tolerance together with appropriate agronomic traits. The morpho-physiological changes in response to drought stress can be used to identify tolerant genotypes to develop new varieties with better productivity under drought stress (Nadeem *et al*., 2019). Plant height, canopy width, number of leaves leaf area, dry biomass are reliable morphological data to evaluate the response of plants to drought stress. While stomatal conductance, transpiration rate, photosynthesis rate, proline content and water use efficiency are physiological plants responses (Anjum *et al*., 2017).

MATERIALS AND METHODS

Accessions and experimental site

The experiment was carried out in a green house at the University Research Station, located in Meewathura, Faculty of Agriculture, University of Peradeniya, during June - December 2018 (*Maha)* under controlled conditions where maximum and minimum temperatures were around 42.7 °C and 17.4 °C, respectively. Ten interspecific hybrids were used which were developed using six cultivated eggplant varieties and three wild relatives as parents with diverse origin (Table 1).

Table 1. Details of the plant materials used in the study

Cultivated Eggplant accessions (*S. melongena* L.)	**Origin**	**Wild relatives**	**Origin**	**Interspecific hybrids**
MEL 2	Ivory Coast	*S. insanum* (INS 1)	Sri Lanka	MEL 2 × INS 1
MEL 3				MEL 3 × INS 1
MEL 4	Sri Lanka	*S. lichtensteinii* (LIC 1)	South Africa	MEL 4 × INS 1 MEL 4 × INS 1 MEL 4 × INC 1 MEL 4 × LIC 1
MEL 5				MEL 5 × INS 1 MEL 5 × INC 1
MEL 6 MEL 7		*S. incanum* (INC 1)	Israel	MEL 6 × INS 1 MEL 7 × INS 1

Experimental design

A completely randomized design was used which consists of 10 interspecific hybrids and three levels of irrigation treatments with three replications. Polybags (25 cm ´ 35 cm) filled with a mixture of top soil : compost : coir dust: half burn paddy husk at the ratio of 5: 3: 2: 1. The optimum water quantity was determined according to Eunice (2014). Irrigation treatments were applied based on the filed capacity (FC) of potting media. Three drought stress levels were adopted based on field capacity namely; I1; FC/ Optimum watering (3.5 L), I2: 70% FC (2.5 L) and I3: 40% FC (1.5 L).

Data Collection

Physiological data and relative water content (RWC) of leaves were measured using the third leaf of main stem of each plant (Matricaria, 2011), Leaf Chlorophyll was measured according to Pirzad *et al*. (2011) and Proline was measured using colorimetric method used by Bates *et al*. (1973). Plant height (cm), plant canopy width (cm), stem diameter (cm), number of green leaves per plant (LPP), number of branches, leaf area were measured as morphological data and yield per plant (YPP/g), Number of fruits per plant (NOF), Mean fruit weight (MFW/g) total soluble solids (TSS) were also measured.

Data analysis

Analysis of variance (ANOVA) was performed using SAS statistical program (SAS 9.1.3 version) at 5% level of significance. Mean separation was done using Duncan Multiple Range test (DMRT).

RESULTS AND DISCUSSION

A highly significant difference was observed between irrigation levels and accessions for all measured traits. Mean performance of all morphological traits including plant height, canopy width, LPP (Fig. 1) and number of branches decreased significantly (at $p<0.05$) from I1 to I3. Drought had the most significant effect on growth traits at I3 and less effect was observed at I2. Drought has been widely reported to hinder growth (Mofokeng and Mokgehle, 2019; Hafeez *et al.*, 2015). The reduction in the LPP and branches under drought stress is another mechanism that plants use to reduce the surface area available for transpiration. This helps to increase water use efficiency in metabolic processes in plant (Pucholt *et al.*, 2015). Proline concentration and Chlorophyll (a, b and total) concentration of leaves was highly significant between accessions and drought stress levels ($p<0.05$) (Fig 2, 3 and 4). Results of the present study is in agreement with Chartzoulakis and Noitsakis, (1993) and Mensah *et al.* (2006). Level of proline concentration was significantly higher in I3 compared to I1 and I2 levels. Accumulation of proline has been reported under the drought stress in eggplant (*Solanum melonogena*) (Laxman *et al.*, 2011). Under water deficit conditions the decline in osmotic potential achieved by solute accumulation such as proline (Heuer, 2010).

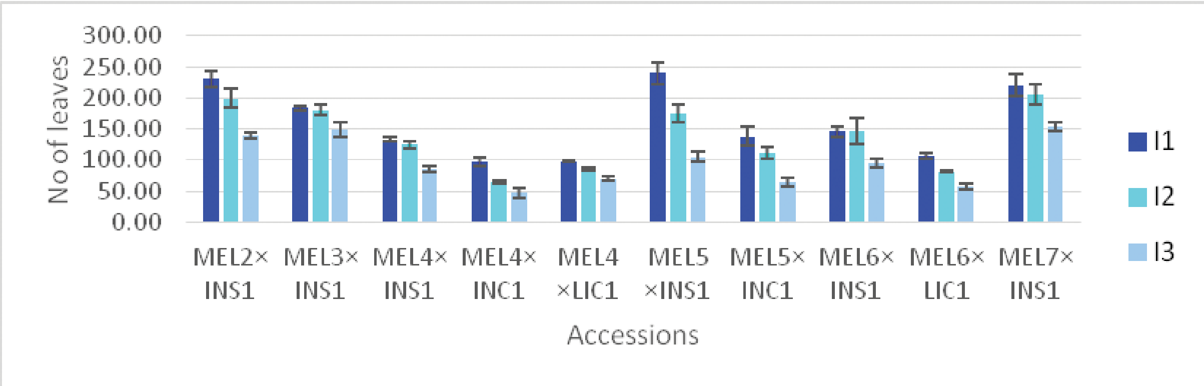

Figure 1. Number of leaves variation under different irrigation treatments

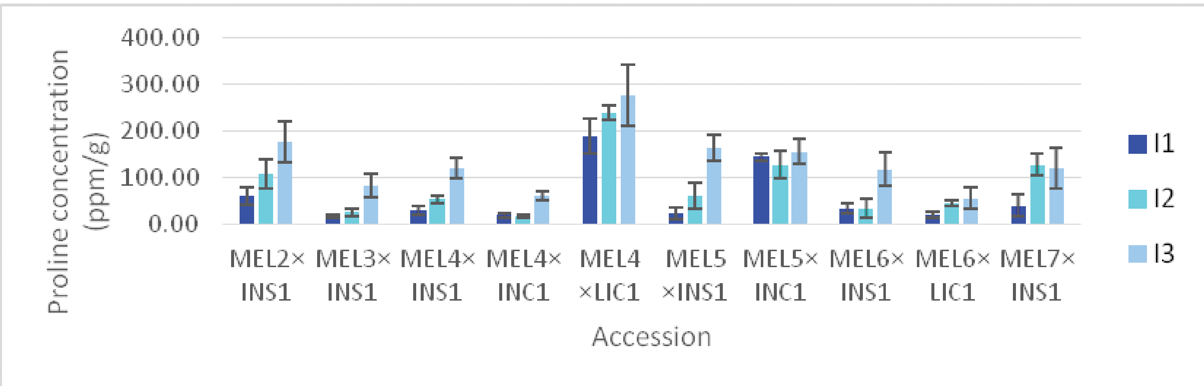

Figure 2. Leaf proline concentration variation under irrigation treatments

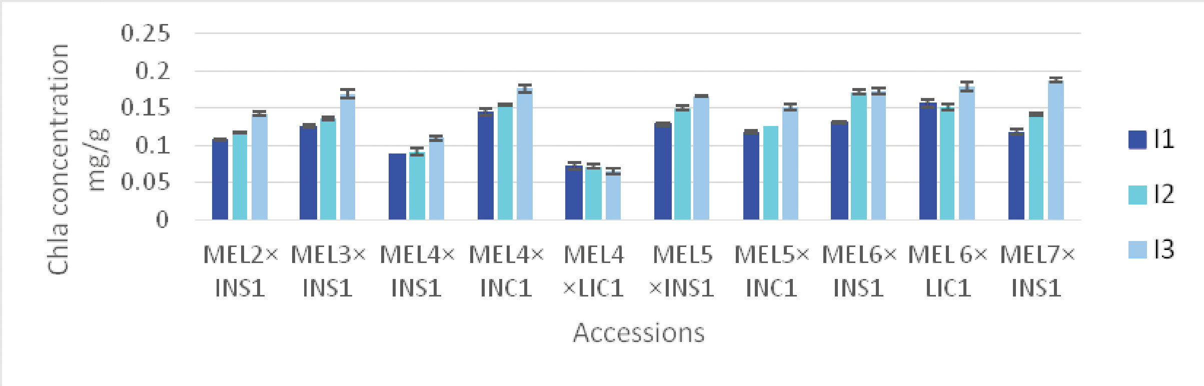

Figure 3. Leaf chlorophyll (a) a concentration variation under different irrigation treatments

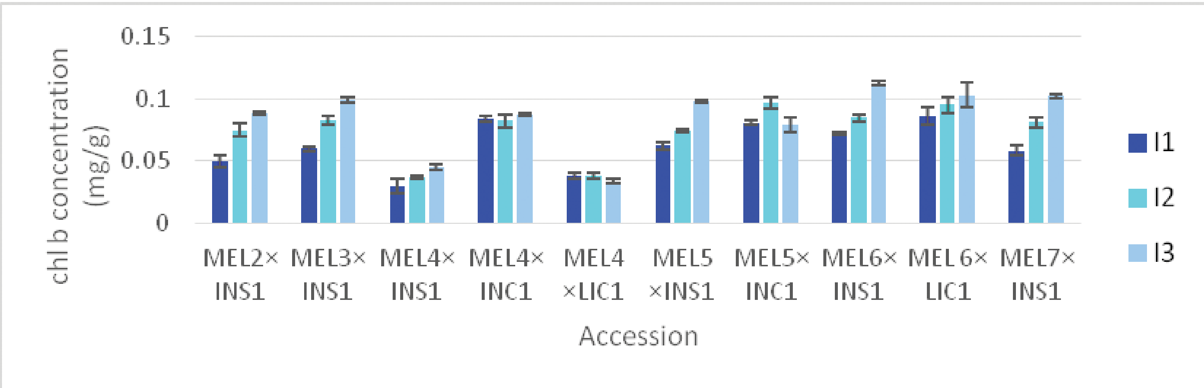

Figure 4. Leaf chlorophyll (b) concentration variation under different irrigation treatments

RWC was significantly different between drought stress levels as well as between accessions (Fig. 5). The high water content maintained by plants under drought stress had produced higher yield (Pirzad *et al.*, 2011).

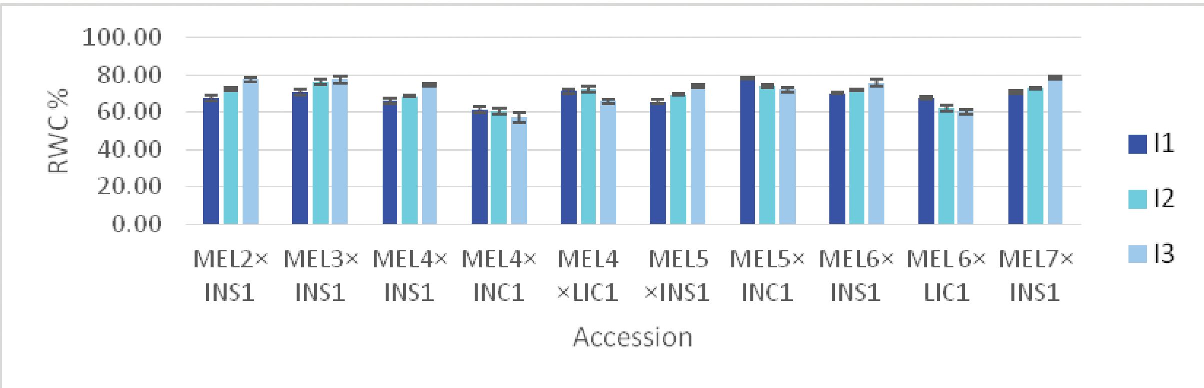

Figure 5. Leaf relative water content variation under different irrigation treatments

YPP (Fig. 6) and NOF (Fig. 7) were significantly reduced from I1 to I3. Moreover, TSS (Fig. 8) was significantly increased ($p<0.05$) as drought stress increased. However, MFW was not affected by the drought stress levels (Fig.9). Drought during vegetative phase affects plant's assimilatory organs, which usually leads to decrease in number and size of the fruits resulting in lower photosynthetic production (Chaves *et al.*, 2003). As a result, yield decreases due to less amount of assimilate available for the developing fruits. Duration of drought stress affect the number of flowers leading to a decrease in the number of fruits and the marketable yield (Bidel, 2014) and premature flower drop (Southwick and Davenport, 1986). According to (Mustapha *et al.*, 2014) drought stressed plants produce chemical substances such as amino acids which lead to increase soluble solids in fruits.

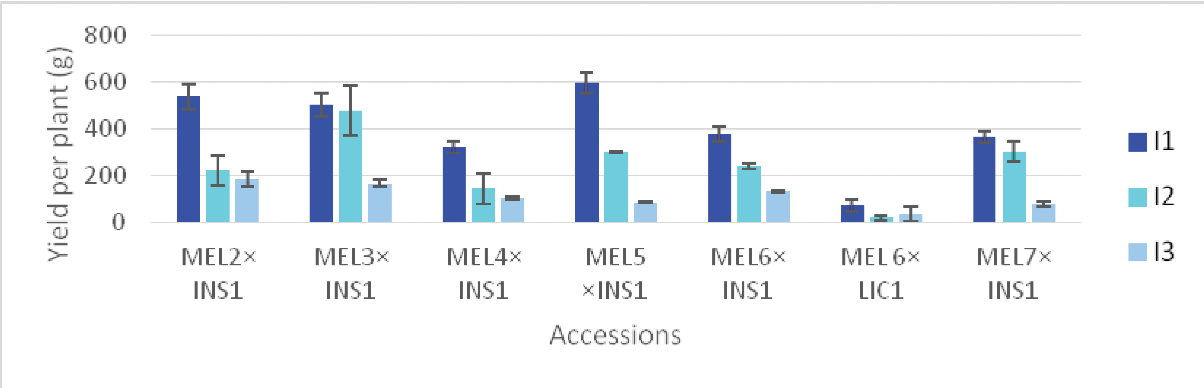

Figure 6. YPP variation under different irrigation treatments

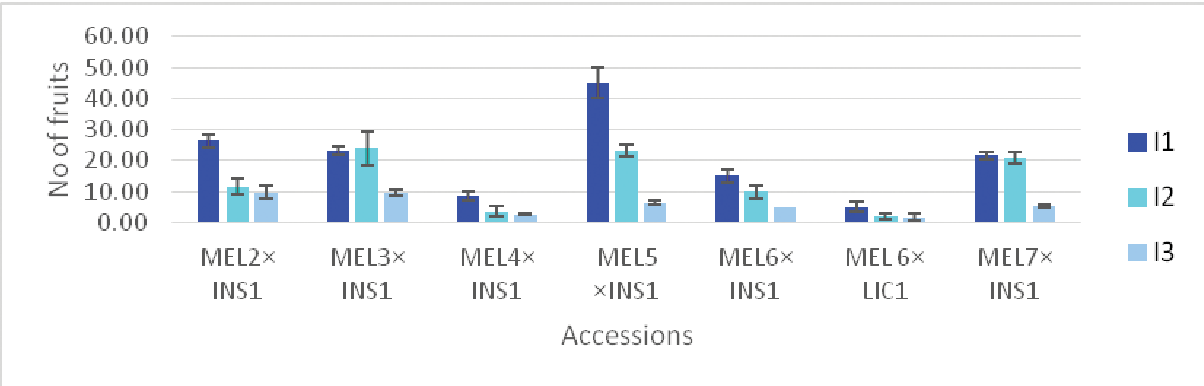

Figure 7. NOF variation under different irrigation treatments

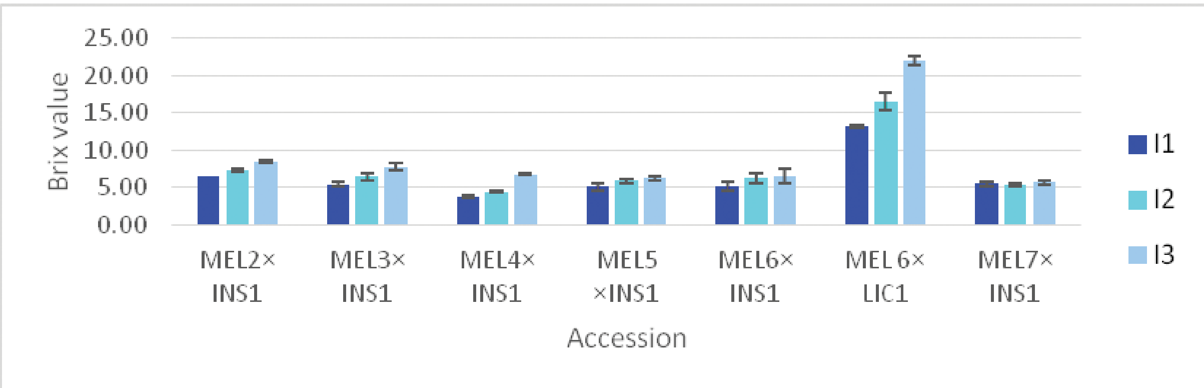

Figure 8. TSS of fruits variation under different irrigation treatments

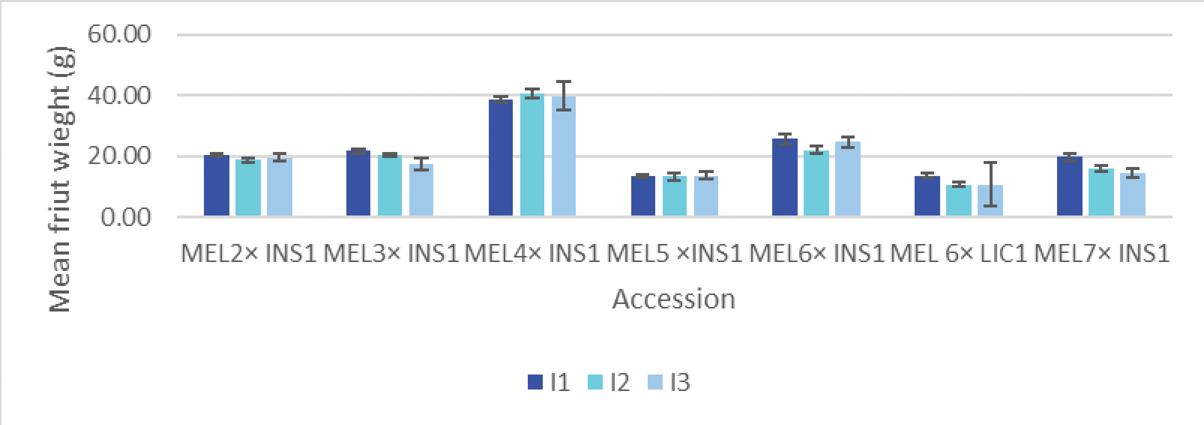

Figure 9. FW variation under different irrigation treatments

The data were analyzed using principal component method. The scree plot shows that the first four factors account for most of the total variability in data. The remaining factors account for a very small proportion of the variability and are likely unimportant (Fig. 10).

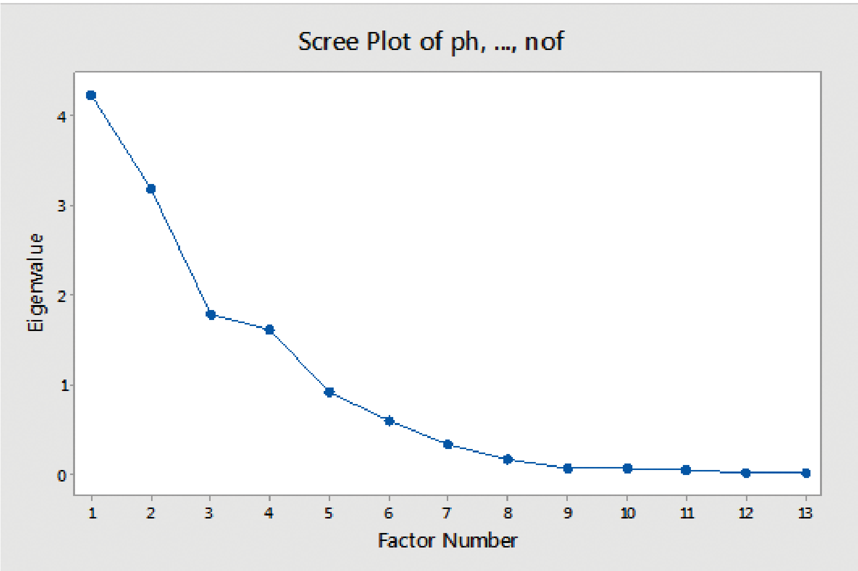

Figure 10. Scree plot under factor analysis where factor 1: LPP, number of branches per plant, plant canopy width, YPP and NOF, factor 2: Chlorophyll concentration (a, b and total), TSS value of fruits and MFW, factor 3: RWC and proline concentration and factor 4: Plant height.

CONCLUSION

Interspecific hybrids MEL2 × *S. insanum*, MEL5 × *S. insanum*, MEL7 × *S. insanum*, MEL7× *S. insanum* and MEL6 × *S. insanum* showed promising morphological and yield characteristics under I1 and I2. Interspecific hybrids MEL3 × *S. insanum*, MEL2 × *S. insanum*, MEL7 × *S. insanum* and MEL6 × *S. insanum* and MEL5 × *S. insanum* showed the highest morphological, physiological and yield characters under I3. Interspecific hybrid MEL3 × *S. insanum*, MEL2 × *S. insanum*, MEL4 × *S. insanum*, MEL6 × *S. insanum* and MEL5 × *S. insanum* have potential to utilize as genetic material for future breeding program related to drought tolerance or avoidance.

ACKNOWLEDGEMENT

This work is completed as part of the project of "Utilization of Crop Wild Relatives in Egg Plant Pre-Breeding for Adaptation to Climate Change" funded by crop diversity trust Germany. I extend my deep sense of gratitude them for providing funding during the research period.

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