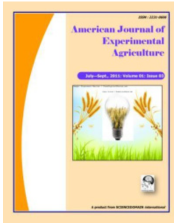

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Effect of Pre-Planting Land Flooding Durations on Growth, Yield and Anatomical Parameters of Three Watermelon [*Citrullus lanatus* (Thunb.) Matsum.] Cultivars

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Research Article

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ABSTRACT

Three watermelon cultivars were grown on land flooded with an irrigation depth 10 cm which was sustained for 1, 2, and 3 week periods before planting date besides, unflooded control land. The obtained results revealed that growing watermelon on land flooded with 2 weeks period was the best, as compared to other flooding treatments. This treatment was exceeded that of unflooded in plant length (47.3%), plant stem diameter (26.9%), leaf area (43.7%), leaf area index (82.8%), fruit number per plant (30%), yield (48.8%), number of stomata in 1 mm^2 (18.3%), number of cells per 1 mm^2 (24.3%) and width of second trichome cell (64.4%), narrowest vessel diameter (28.75%). Moreover, this treatment revealed superiority over 1week flooding period in stem dry matter percentage (26.9%), narrowest width of vessel (27.84%), highest vessel width (12.12%). Two week flooding period also overwhelmed that of 3 week period in fruit number per plant (26.2%), width of narrowest vessel (12.84%) and width of hair second cell (43.7%). Subsequently, this treatment can be categorized as the first treatment in the sequence order. One week flooding period treatment comes next in the order. This treatment preponderated that of unflooded treatment in branches number per plant (19.8%), leaf fresh weight (47.1%) and number of cells at 1 mm^2 in upper leaf surface (15.3%). Furthermore, this treatment was exceeded that of 3weeks period in number of branches per plant (24.8%). controls and 3 weeks flooding treatments were the worst and they inferior to others. Noura appeared to be the best positively responded cultivar to dry land cultivation as compared to other evaluated cultivars. This cultivar substantially exceeded Charlee cultivar in term of fruit individual (22.2%), rind weight (31.5%), rind thickness (9.2%), number of stomata in 1 mm^2 (9.8%) the widest vessel diameter (20.5%) and number of xylem vassels (9.9%). Additionally, it profoundly surpassed Glorry cultivar in fruit flesh weight (29.1%), fruit diameter (12.3%), rind weight (22.4%),

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number of stomata in 1 mm^2 (10.2%) and widest vessel diameter (15.19%) and number of xylem vassels (7.9%). Glorry water melon comes next in the category order. This cultivar was paramount to Charlee in term of plant stem diameter (19.1%). Therefore, Charlee was the worst responded cultivar and the order according to cultivar capabilities in drought resistance are as the following. Noura > Glory > Charlee. The best dual interaction treatment was growing Noura cultivar on land flooded for 2 week with water height of 10cm which manifested superiority over other treatments. Since it gave the highest (plant length (215cm), leaf dry matter percentage (22.13), fruit length (26 cm), yield (0.87 kgm^{-2}), number of stomata in 1 mm^2 (220), number of cells in 1 mm^2 (819.5) and widest diameter of xylem vessels (11micron).

Keywords: Watermelon cultivars; drought; Rainfall; water stress; anatomy; land flooding;

1. INTRODUCTION

Watermelon belongs to the family *Cucurbitaceae* and the genus *Citrullus* and it's the only cultivated species of this genus (Bisognin, 2002). It is believed to have originated in Africa but is now widely spread throughout the tropics and the Mediterranean (Tindall, 1983). Watermelon is thought to have been domesticated in Africa at least 4000 years ago and now grown worldwide, particularly in regions with long, hot summers (Robertson, 2004; Huh *et al.*, 2008). Its global consumption is greater than that of any other cucurbit. It accounts for 6.8% of the world area devoted to vegetable production (Guner and Wehner, 2004). China is the leading country in production of watermelon followed by Turkey, United States, Iran and Republic of Korea (Wehner and Maynard, 2003). The total area harvested of watermelon in Iraq in 2008 was 36300h. Whereas; harvested areas in China, Syria and Jordan were 2162456, 24000 and 2145h, respectively. The corresponding watermelon productions to the above cultivated areas were 455712 MT in Iraq during 2008. While the production of China, Syria and Jordan reached to 67203275, 366700 and 97599 MT, respectively (FAO. 2010).

100g watermelon contains water 91.45g, energy 30kcal, protein 0.61g, total lipids 0.15g, ash 0.25g, carbohydrate 7.55g, fiber 0.4g, and its also a good source of vitamins A and C, and provides potassium. Watermelon is rich in carotenoids, some of the carotenoids in watermelon include lycopene, phytofluene, phytoene, β-carotene, lutein, and neurosporene. The carotenoid content varies depending on the variety, carotenoid content in red fleshed watermelon varies from 37-121$mg.kg^{-1}$ fresh weight, where as lycopene varies from 35-112$mg.kg^{-1}$ fresh weight. Lycopene makes up the majority of the carotenoids in watermelon, it is an antioxidant that may help the body fight cancer and prevent disease owing to its cell ROS scavenging actions. Watermelon health benefits resided in its citrulline content, which enters the urea cycle, and helps treat a variety of disease, especially kidney-related disease (USDA, 2006).

Water deficit (commonly known as drought) can be defined as the absence of adequate moisture necessary for normal plant grow and to complete the life cycle (Zhu, 2002). In higher plants the oxygen toxicity is more serious under condition of water-deficit conditions. Water stress causes stomata closure, which reduces the CO_2/O_2 ratio in leaves and inhibits photosynthesis (Jason *et al.,* 2004). The lack of adequate moisture leading to water stress is common occurrence in rain fed areas, brought about by infrequent rains and poor irrigation. These conditions increase the rate of reactive oxygen species (ROS) like superoxide radical

(O_2^-) hydrogen peroxide (H_2O_2), and hydroxyl radical (OH-) particularly in chloroplast and mitochondria (Mittler, 2002), via enhanced leakage of electrons to oxygen.

Plant can avoid drought by varying mechanisms, some mechanisms are naturally created namely C_4 and CAM photosynthesis patterns. Plants self defense mechanisms are also adopted by stomata behavior where plants can immediately close stomata (conservative plants), semi stomata closure (semi-conservative plants) and manifesting rapid root growth to occupy large soil. Other crops tend to complete their life cycle before severe drought is experienced (drought escape crop) such as determinate cultivars and species. Anatomical and morphological modifications also can be considered as drought mechanism for instance dwarfing, leaf rolling and folding, thick cuticle, sunken stomata, and heavy trichome multiple epidermises, double palisade layers of mesophyll and tough stature of leaves (Jenks and Hasegawa, 2005).

Since water shortage or stress constitute a major problem facing agriculture crop productions, particularly in sub tropical semiarid region where Iraq is located, climate change now a day aggravated the problem owing to the drastic reductions in rainfall incidences in northern Iraqi region. Therefore, the objective of this study was to find: Is it possible to produce watermelon under rainfall incidences in Duhok governorate, can we aid watermelon production under rainfed conditions by increasing the stored soil moisture, are there any differences responses in cultivars to soil water shortages, and which cultivar shows better performance under drought conditions in order to discriminate drought resistant from susceptible cultivars through the detection of anatomical and morphological alteration in traits in response to water scarcities.

Water stress imparts more adverse influence on fruit set and early yield than on leaf and vine growth (Leskovar and Meiri, 1995). Moreover, water stress during early fruit development can result in small, misshapen fruit, and the occurrence of blossom end rot (a physiological disorder in which the blossom end of a fruit ceases to grow and becomes dark and leathery). As harvest approaches care must be taken to avoid large fluctuations in soil moisture content, as heavy irrigation (or rainfall) can result in fruit splitting. After crop establishment (either by seed or transplant), irrigation may be withheld for a period of several weeks to encourage deep rooting. However, irrigation should be managed to minimize water stress throughout the fruit set and fruit sizing periods (California, 2009).

The objective of this trail was to find out the possibility of cultivating three watermelon cultivars under rainfall incidence and/or with the aid of varying pre-planting land flooding levels besides the detection of drought resistance and susceptible watermelon cultivars.

2. MATERIALS AND METHODS

This investigation was carried out during the grown season of 2009 at the field of Horticulture Department, Agriculture College, Duhok University, Dohuk which is located at (36°51"38') North Latitude and (42°52"02') East longitude, and with altitude of 473 m.

Seeds of three watermelon (*Citrullus lanatus*) cultivars namely NOURA, GLORY, and CHARLEE were purchased from agricultural bureau, Duhok. These cultivars are very popular among Dohuk growers, seedless fruit type, elongated gray fruits and possess a prostrate growth habits. The first Noura cultivar was produced by Rossen Seed Company, Holland with lot number 5335, germination date and percentage 2008, 85%, respectively; while the second GLORY GUMBO was produced by TAKII LTD seed company, KYOTO, Japan, 85% germination tested on 2008. This cultivar is newly introduced to Dohuk growers possesses globe gray fruit, seedless type and prostrate growth habits. Finally the third cultivar was CHARLEE produced by Peto Seed US Company, under lot number 990901, 90% germination dated on September, 2007. This cultivar is seedless, gray elongated fruits, prostrate growth habits and highly adapted all around Iraqi provinces, particularly in Kirkuk and Khalis.

Split within Factorial Randomized Complete Block Design (split, F-RCBD) was selected where the main plot (A) was the flooding treatment: (a_1). Control Un-flooded soil rainfed only (Control). (a_2). Plot was water flooded by sustaining 10 cm of water over soil surface for one week period, (a_3). Plot was flooded by sustaining 10 cm of water over soil surface for two weeks, (a_4). Plot was flooded by sustaining 10 cm of water over soil surface for three weeks. The sub main plot was watermelon cultivars B: NOURA (b_1), GLORY (b_2) and CHARLEE (b_3). Subsequently (4*3) =12 treatments were included in this experiment; each treatment was replicated four times. A replicate was represented by one plot 6m length and 3m width and 1 m plant intra space.

Permanent field soil was plowed vertically and horizontally once more then field was dissected to fit the proposed design, and therefore field was put into four main plots separated from each other with 4m spaces to avoid water seepage among them. While the permanent field is prepared, the preparations of transplants were conducted inside the controlled greenhouse. Subsequently, pots of 12cm diameter were filled with a mixture of sandy soil: peat mosses then, they were brought up to field capacity before sowing the included cultivar seeds on March 3rd, 2009. Watermelon plants were transplanted to the permanent field April 8th, 2009 when the overwhelming environment be ensured that no chilling harm will be occurred.

Watermelon transplants were planted in each flooding treatment on 6m line length with one meter intra plant space and thy same line and with 3m between lines. Gypsum blocks were distributed with in flooding plots, in each replicate 3 gypsum blocks were settled at depths of either 0.5, 1 and/or 1.5m in order to track soil moisture depletion during the growing season. NPK 18:11:5 fertilizer was applied at rate five (gm/m^2). Beltanol used with a rate of one ml.l^{-1} to control soil borne diseases. Continuous manual weed eradication was made around the growing season. Experiment was terminated on November 25th, 2009.

Table 1. Maximum and minimum temperatures during the period of the study in Sumeil area Duhok Governorate (2009)

Month	Max. Temperature	Min. Temperature	Rainfalls Depth (mm)
March	15.5	4.6	63.3
April	24.4	9.1	35.7
May	32.1	13.1	-
Jun	36.56	21.75	-
July	41.2	21.7	-
August	39.9	18.9	-
September	34.9	14.25	-
October	30.6	12.4	1.11
November	18	8.15	2.8

Table 2. Some selected physical and chemical properties of the soil at the experimental site

Parameters		Average value
Practical size distribution	Sand g Kg^{-1}	84
	Silt g Kg^{-1}	415.0
	Clay g Kg^{-1}	501.0
	Texture	Silty clay
Moisture content at field capacity		30%
Moisture content at wilting point		18.25%
Organic matter g kg^{-1}		15.86
PH		7.8
Cation exchange capacity (cmole kg^{-1})		33.69
Electrical conductivity (dS m^{-1})		0.397
Calcium carbonate g kg^{-1}		244.5
Soluble Cations (mmole/L)	K^{+}	0.115
	Na^{+}	0.913
	Ca^{2+}	1.4
	Mg^{2+}	0.45
Soluble (mmole/L)	Cl^{-}	1.8
	HCO_3^{-}	2.4
	$CO3^{2-}$	Nil
	SO_4^{-}	0.265

Maximum and minimum temperature were recorded through the period of study was shown in Table 1 and sum selected physical and chemical properties of the soil at the experiment site in the Table 2 & 3 (Atroshy, 2010).

Measurements including leaf number per plant, stem number and fruit number were counted. Plant height, plant length were measured by ruler, while fruit diameter, rind thickness, stem diameter, were measured by caliper. Leaf fresh weight, rind fresh weight, weight of edible tissue, were weighted by metric balance two decimals. Leaves and stems dry weight was weighted after being oven dried at 70°C for 72 hours. Then samples were taken out from the oven and left for two hours then weights were reviewed in order to calculate the dry matter percentage.

Light microscope, metric slide and graded lens 7X, 40X magnification lenses were used to determine stomata dimensions. The eye lens 7X was dissected into 10 fractions each is subdivided into 10 parts and one part is found to equal 0.9 micron. Full expanded leaves were sampled from the watermelon plant on August 7th to November, 11th. At eight o'clock sample were weighted in Petri-dishes and left in the refrigerator at 5°C.

Epiderm of the fresh leaves was pealed on the leaves by forsept and knife and then mounted on the slide at rob of distilled water were added and the sample was slightly covered by slide cover, then the slide was witted with tissue tall cover and examined under object length of 40x and grade eye 7x. Then stomata was magnified 7x40= 280 times (Abdel, 2007).

Permanent slide preparation was commenced by leaf petiole sampling on September 2nd, then tissues were killed, fixed, wax embed as the recommended by Berlyn and Miksche

(1976). Leaf water potentials were determined through varying sucrose concentrations (Wotham et al., 1986).

Core was used to take a given soil volume of known weight at field capacity. The soil sample was weighted after being dried in oven at 105°C. Then Soil bulk density was calculated. Gypsum blocks calibration was made by taking soil samples from 0.5, 1 and 1.5m depth were mixed perfectly then pot of 9cm in diameter was filled with this soil.

Gypsum block was settled at the mid depth of the soil filled pots. 10 pots were brought up to field capacity by watering them and then they were sealed with black polyethylene bags and left for 24 hrs and weighed to record the reading of (Avometer brother YH-395B) corresponding to field capacity then pots were left to dry. Readings for both pot weights and their corresponding current resistance were recorded daily while the soil drying was progressed until pot weight reading differences were vanished. Soil available water capacity (AWC) was calculated from the mean of pot weight at field capacity minus pot weights at soil drying phase. AWC depletion percentage was calculated from the following equation (Abdel, 2007).

Soil weight at field capacity – soil weight at any given time/ soil weight at FC- dry soil weight x100. This equation was applied after each reweighing and table of resistance in ohm column versus AWC depletion percentage were emerged. Finally, recorded data was analyzed by computer Minitab Regression programmer (Figure 1).

Stomata populations were determined by counting the stomata number in the micron area of examined leaf sample under the microscope and then converted to square millimeter, referring to micrometric slide dimensions of sample area (Abdel, 2007).

Leaf area was calculated by weighting the whole fully expanded (4^{th} down order from the apical meristem) leaf of watermelon and then one centimeter was cut out including the midrib leaf and weighted (Dvornic, 1965). The area was calculated from the following equation: LA = leaf weight/weight of $1cm^2$ of leaf cut. Leaf area index was calculated from the following equation (Abdel, 2007): Leaf area cm^2 x leaf number per plant/space between rows cm x intra plant space within the row cm.

TSS hand Refrectometer was calibrated by distilled water then used to measure the TSS (Link operation Manual) made in chain. A sap drop of edible fresh tissue was placed in the device and TSS % was recorded for each sample.

Total sugar was estimated by taking 1 ml from the juice by a 1ml sized pipette in to a test tube > then 1 ml of phenol (5%) , dist water and 5ml of concentrated sulphuric acid (97%). It was put in water bath at 60 C° for 30 minutes and then moved to the center fuge apparatus (30r/min). It was left until being at room temperature. Then the infiltrated was isolated and the reading were recorded by the spectrophotometer at a wave length of (490) nanometer. Stock solutions were prepared as well for making a standard carve a cording to (Joslyn, 1970).

Chlorophyll was determined in the field using (chlorophyll meter, model SPAD 502 manufactured by Minolta company Japan (ch% out of leaf pigments).

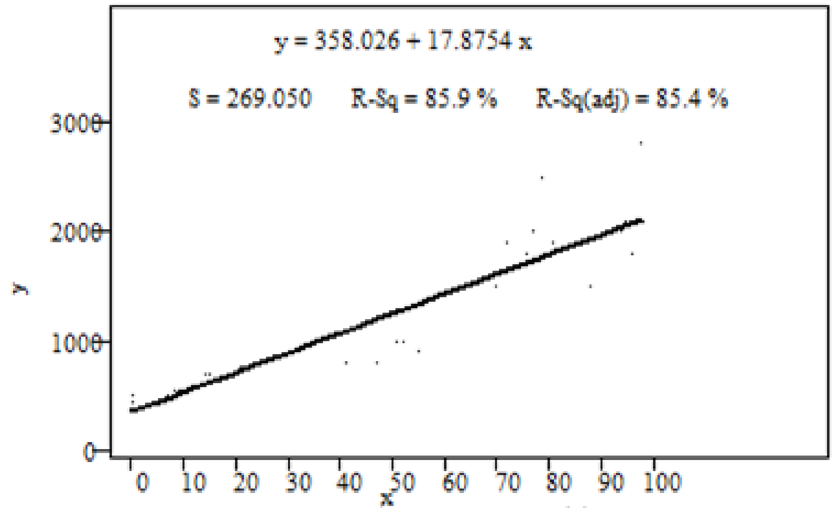


Fig.1. Plot of soil AWC depletion percentage (x) versus gypsum block record OHM (y) at a depth beyond 0.5m

3. RESULTS AND DISCUSSION

3.1 Effect of Flooding on Growth

3.1.1 Effect of land flooding

The obtained results (Table 4 and Figure 2) revealed that land flooding for two weeks before planting was the most potent treatment. It exceeded that of control treatment in plant length (47.3%); leaf area (43.7%) and leaf area index (82.8%). Furthermore, it by passed the one week soil flooding in stem dry mater (26.9%). However, unflooded land treatment was superior over this treatment in stem diameter (22.4%). Treatment of land flooded for 1week came next to that of 2 weeks in the superiority order. It exceeded that of unflooded in term of plant branch number (19.8%), and leaf fresh weight (47.1%). In addition to that this treatment revealed superiority over 3weeks land flooding treatment in branches number per plant (24. 8%). Non-significant differences were observed between this treatment and that of 2weeks flooding land in term of plant stem diameter, leaf number, leaf dry matter percentages. However, this treatment gave substantially lower plant stem dry matter (25.7%), as compared with check. Unflooded land treatment was categorized as the third order in water melon growth performance. Since it apparently exceeded that of 3 weeks land flooding in plant stems dry matter (26.4%). Finally, the worst treatment was 3 weeks land flooding as it manifested the lowest values in most detected growth traits. The variations among land flooding treatments might be attributed to two overwhelming factors the first may be due to the departure of some of the available minerals down beyond the watermelon effective root zone. While the second factor may be long flooding period resulted in effective soil bulk density increases which might be reflected upon root performance owing to the low aeration. Combination of the above two factors may aggravate the adverse effects. However, regardless to nutrition and aeration shortages still drought is the primary causative for growth reductions. Since it is preponderated the divergence of almost all cell metabolisms. Under water stress conditions, an imbalance between production and scavenging of reactive oxygen species (ROS) leads to oxidative stress. Therefore, reducing power in the form of NADPH is required latter by the antioxidant ascorbate/glutathione pathway, which implies that both oxidative pentose phosphate pathway (OPPP) and Isocitrate dehydrogenase (ICDH) activity might be of crucial relevance. Since its function as a carbon skeleton supplier, ICDH activity in water stressed pea nodules may provide an indication of the C/N balance within nodules under these conditions (Moran et al., 1994).

3.1.2 Cultivar responses

Non-significant differences were observed in the detected traits relevant to growth performance of watermelon accept that Glory watermelon cultivar was profoundly by passed Charlee cultivar in term of plant stem diameter (19.1%), which could be attributed to the genome expression capability of this cultivar in such conditions.

3.1.3 Cultivar responses to land flooding

Charlee watermelon cultivar grown on land previously flooded for 1week appeared to be the most potent treatment, as it gave the highest values in most of the detected traits. It significantly exceeded that of unflooded Charlee in terms of branches number per plant (40%), leaf number (117.1%), leaf area index (361.9%), and leaf fresh weight (168.%). On the other hand the worst treatment was Charlee cultivar grown on un flooded check, since the lowest values of most detected parameters were confined to this treatment, for instance, plant length (98.75cm), leaf number per plant (237.25), leaf area (11.82 cm^2), leaf area index (0.84) and leaf fresh weight (0.25g). These results could be attributed to the influence of drought on cell growth which finally reflected on plant growth parameters. Cell expansion in developing organs is driven by water uptake into the central vacuole and involves a massive enlargement of the cell wall through biosynthesis and deposition of new wall material (Menand and Robaglia, 2004). An increase in cell wall elasticity can also contribute to turgour maintenance under drought conditions (Patakas and Noitsakis, 1997). In elastic cell walls although preclude turgour maintenance to low water contents, they do have several advantages over elastic cell walls and may become together with osmotic adjustment an efficient mechanism which enable plants to sustain water stress conditions (Meier et al., 1992; Grossnickle and Russel, 1996).

3.2 Effect of Flooding on Fruiting

3.2.1 Effect of flooding

The obtained results (Table 5) revealed that land flooding for two weeks before planting was the most potent treatment. It exceeded that of control treatment in fruit number (30.0%), yield (48.8%). In addition to that this treatment revealed superiority over 3 weeks land flooding treatment in fruit number (26.2%). However, un-flooded land treatment gave higher rind weight (58.2%), in comparison to that obtained from 3 week land flooding. Yield reductions under water stress were previously documented in onions (Abdel and A-l Juboori, 2006), Cowpea (Abdel and Al-Salem, 2010), Faba bean (Abdel and Al-Hamadany, 2010). They attributed their results to many factors including cell expansions, stomata and non stomata factors which finally reflected on photosynthesis.

Noura control Date on 10/8/2009

Glory on 3 week flooded Date 2/11/2009

Fig. 2. Growth of three watermelon cultivars revealing the extent of drought and crop stature

3.2.2 Cultivar responses

Noura cultivar exhibited the highest response to varying land flooding, as it surpassed Glory cultivar in edible fresh weight of fruit flesh (29.1%), fruit diameter (12.3%) and rind weight (22.4%). Additionally, this cultivar manifested superiority over Charlee cultivars in rind weight (31.5%) and rind thickness (9.2%). Insignificant differences were recorded among investigated cultivars for the rest traits. The obtained results might be attributed to cultivar capabilities in genome expressions under drought circumstances, obviously theses abilities are usually dependent upon purity degree and the precise technique that had been utilized by producer. Drought resistance capability of any cultivar relied on its ability to match with water scarcity condition by which reasonable growth that could be achieved. Previous studies revealed that water deficits can induce wall loosening and wall hardening responses in adjacent regions along the elongation zone of developing roots. Wall loosening may decrease the inhibitory effect of water deficits on root growth. The wall hardening responses in the more mature regions of the root elongation zone are associated with the production of smaller mature cells and the overall inhibition of root elongation rates (Neumann, 1995).

3.2.3 Cultivars responses to flooding

The most effective treatment was Noura watermelon cultivar grown on land previously flooded for 2 weeks, since it gave the highest yield (0.87kgm^{-2}). This treatment revealed preponderance over Glory 3 weeks flooded in yield (86.9%), Charlee 1 week in fruit length (44.4%). The worst treatment was glory cultivar grown on 3 weeks flooded land, as it manifested the lowest yield (0.4627 kgm^{-2}), rind weight (321.5g), fruit diameter (11.75). Field observations revealed that all cultivated watermelon cultivars were substantially depressed when high light intensities, severe drought and extremely high temperatures (Table 7 and Figure 3), were combined together against growth during July and August. Therefore, the generated fruits were small, apparent cracked and blossom end rots (Figure 2). However, latter on September, plant lushes were observed in the field where the plants resumed perfect growth, as newly branches that bearing flowers and then fruit were generated. These results were due plant development requirements which were highly dependent on assimilate source and sink, in fact photosynthesis under drought is profoundly inhibited as results of the many factors including stomata and non- stomata factors.

The relieved mesophyll resistance when leaves are re-watered may explain the high photosynthesis (Pn) for intercellular CO_2 concentration Ci similar to those of stressed leaves during recovery. Changes in leaf anatomy likely affect the conductance to CO_2 diffusion (Evans *et al.,* 1994 and Syvertsen et al., 1995). There was also a clear correlation between leaf photosynthesis (Pn) and intercellular CO_2 concentration (Ci), but leaves recovering from water stress showed a much higher Pn rate, if compared with the stressed leaves at the same Ci. However, cv. Hass exhibited higher Pn rates at the same level of water stress than cv. Fuerte. There was a strong inverse correlation r^2 ¼ 0:61 between photosynthesis of control and stressed plants and CO_2 draw-down. Photosynthesis as well as stomata conductance of cv. Fuerte fully recovered 2 days after re-watering, while in cv. Hass plants attained 20% lower values than that of the control (Chartzoulakis et al., 2002).

3.3 Anatomical Alterations

3.3.1 Effect of flooding

The obtained results (Table 6 and Figure 4) showed that flooding land for two weeks in advanced to planting was the most potent treatment. It profoundly exceeded that of control treatment in terms number of stomata in 1 mm^2 (18.3%), number of cells per 1 mm^2 (24.3%) and in the width of second cell trichome hair (64.4%), of narrowest diameter of xylem vessel (28.75%), Furthermore, it substantially surpassed 1 week flooded treatment in narrowest xylem vessel diameter (27.84%) and widest diameter of xylem vessels (12.12%). It also displayed superiority over 3 weeks land flooding treatment in the width of second cell in trichome hair (43.70%), in widest xylem vessel diameter (12.84%) and vessel number (11.1%). Stomata behavior in response to tissue dehydration had been considered as early alarm in the commencement of drought. Hence, drought susceptible and/or drought resistance cultivars can be distinguished from stomata dimensions, aperture, and populations (Abdel, 2009). He stated that complete stomata closure, semi-closure and opened stomata are synonymous, respectively to conservatives, semi conservatives and spender types of drought avoidance. In agriculture productions semi conservatives are preferred owing to their capabilities in sustaining acceptable photosynthesis. It was found that maximum and minimum stomata resistances were 3.195 and 1.447 S/cm in irrigation after 210 and 70 mm evaporation, respectively. Stomata resistance increased with ABA production enhancement as a result of turgor pressure decrease in water stress condition is the reason of this fact. Stomata resistance also increased with gradual decrease in stomata size. If one leaf is exposed to water deficit condition, the moisture of subsidiary cells will decrease, and consequently stomata diameter, leaf area and relative water content decrease and stomata resistance increase, which resulted in decrease of seed yield. The above results are in agreement with those obtained by Mojayad and Planchon (1998), Lahlou et al. (2003), and Khalilvand and Yarnia (2007).

Table 3. The soil bulk densities ($g.cm^{-3}$) of varying treatments and varying soil depths

Soil	Control			1 week			2 week			3 week		
depth (m)	Noura	Glory	Charlee	Noura	Glory	Charlee	Noura	Glory	Charlee	Noura	Glory	Charlee
0.5m	1.36	1.46	1.42	1.35	1.40	1.42	1.41	1.43	1.42	1.45	1.43	1.39
1m	1.41	1.53	1.54	1.56	1.56	1.57	1.51	1.52	1.47	1.54	1.58	1.51
1.5m	1.56	1.64	1.61	1.62	1.63	1.62	1.63	1.55	1.60	1.61	1.61	1.59

Fig. 3. Blossom end roots and cracking of watermelon fruits physiological disorders and small sized fruits owing to water stress

Table 4. Vegetative parameter responses of Noura, Glory and Charlee watermelon cultivars to varying pre-planting land flooding durations

Treatments	Varieties			
	Plant length (cm)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	121.75 bc	187.25 ab	98.75 c	135.92 b
1- week	135.50 abc	196.50 ab	172.25 abc	168.08 ab
2- week	215 a	171.25abc	214.50 a	200.25 a
3- week	205 ab	125.25 bc	137 abc	155.75 ab
Mean cultivars	169.31 a	170.06 a	155.63 a	
	Plant stem diameter (mm)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	2.25 b	3.37 a	2.5 ab	2.7 ab
1- week	2.37 ab	2.87 ab	2.25 b	2.49 b
2- week	3 ab	3.25 ab	3.25 ab	3.16 a
3- week	3.37 a	3 ab	2.5 ab	2.95 ab
Mean cultivars	2.75 ab	3.12 a	2.62 b	
	Branches number per plant			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	11 abc	11.75abc	8.75 c	10.5 b
1- week	10.75abc	13ab	14 a	12.58 a
2- week	10 bc	13 ab	12 abc	11.66 ab
3- week	11.5abc	9.25 bc	9.5 bc	10.08 b
Mean cultivars	10.81a	11.75a	11.06 a	
	Plant stem dry mater percentage %			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	15.72 ab	18.71 a	15.9 ab	16.78 a
1- week	15.54ab	12.39 b	12.12 b	13.35 b
2- week	12.92 b	13.83 b	14.39 b	13.71 b
3- week	13.5 b	12.51 b	13.83 b	13.28 b
Mean cultivars	14.42 a	14.36 a	14.07 a	
	Leaf number per plant			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	331.5 bc	458.25 ab	237.25 c	342.33 a

1- week	408 abc	330.50 bc	515.75 a	418.08 a
2- week	443.50 ab	410.75 abc	351.75 abc	402 a
3- week	395.5 abc	324 bc	402.5 abc	374 a
Mean cultivars	394.63 a	380.88 a	376.81 a	
		Leaf area (cm)		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	17.68 a	15.45 a	11.82 a	14.99 b
1- week	17.08 a	22.24 a	22.71 a	20.68 ab
2- week	23.44 a	20.54 a	20.65 a	21.54 a
3- week	19.22 a	18.12 a	23.52 a	20.29 ab
Mean cultivars	19.36 a	19.09 a	19.68 a	
		Leaf area index		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	1.83 ab	2.38 ab	0.84 b	1.69 b
1- week	2.43 ab	2.53 ab	3.88 a	2.95 ab
2- week	3.68 a	3.23 a	2.36 ab	3.09 a
3- week	2.27 ab	1.97 ab	3.27 a	2.508 ab
Mean cultivars	2.56 a	2.53 a	2.59 a	
		Leaf dry meter percentage %		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	21.8 a	20.1 ab	19.36 ab	21.41 a
1- week	18.74 ab	19.45 ab	14.85 b	17.68 a
2- week	22.13 a	20.72 ab	18.4 ab	20.42 a
3- week	14.83 b	19.54 ab	16.68 ab	17.03 a
Mean cultivars	19.88 a	19.97a	16.83 a	
		Individual leaf fresh weight (g)		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	0.39 ab	0.37ab	0.25b	0.34 b
1- week	0.41 ab	0.54 a	0.67a	0.50 a
2- week	0.47 ab	0.44 ab	0.43 ab	0.45 ab
3- week	0.41 ab	0.39 ab	0.49 ab	0.43 ab
Mean cultivars	0.423 a	0.438 a	0.436 a	

*Note: *Numbers followed by the same letters in the same column are significantly not different according to Duncan's multiple range tests at 0.05 levels.*

Table 5. Responses of Noura, Glory and Charlee watermelon cultivars to varying land flooding period before planting in terms of yield component parameters

Treatments	Varieties			
		Fruit number		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	8 a	9.25 a	7.75 a	8.33 b
1- week	8.25 a	11.75 a	9.25 a	9.75 ab
2- week	9.75 a	11 a	11.75 a	10.83 a
3- week	8.5 a	8 a	9.25 a	8.58 b
Mean cultivars	8.63 a	10 a	9.5 a	
		Fruit individual (g)		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	1776.8 b	1735.3 b	2033.5 ab	1848.5 a
1- week	2179 ab	2085.3 ab	1655.8 B	1973.4 a
2- week	2669.8 a	1615.8 b	2048 ab	2111.2 a
3- week	2684.3 a	1776.3 b	1882.8 b	2114.4 a
Mean	2327.5 a	1803.1 b	1905 b	
		Fruit length (cm)		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	19 b	19.75 ab	21 ab	19.92 a
1- week	20.75 ab	21.5 ab	18 b	20.42 a
2- week	26 a	20.5 ab	22.25 ab	22.92 a
3- week	23.4 ab	18 b	19 b	20.22 a
Mean cultivars	22.29 a	19.94 a	20.13 a	
		Fruit diameter (cm)		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	13..12 abc	12.25 bc	14.37 ab	13.29 a
1- week	14.12 ab	13.07 abc	13.87 abc	13.69 a
2- week	14.5 ab	13.25 ab	13 abc	13.58 a
3- week	14.75 a	11.75 c	12.37 bc	13.96 a
Mean cultivars	14.13 a	12.58 b	13.41 ab	

	Rind weight (g)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	686.8 ab	574.8 abcd	796 a	685.87 a
1- week	693 ab	636.8 abc	411.8 cd	580.53 ab
2- week	633 abc	623 abc	445 bcd	567 ab
3- week	626 abc	321.5 d	353.3 d	433.58 b
Mean cultivars	659.7 a	539 b	501.53 b	
	Rind thickness (mm)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	5.77 a	5.5 abc	5.9 a	5.72 a
1- week	6 a	5.82 a	4.85 bc	5.56 a
2- week	5.37 abc	5.5 abc	5.52 abc	5.47 a
3- week	5.75 ab	5.27 abc	4.7 c	5.24 a
Mean cultivars	5.72 a	5.52 ab	5.24 b	
	Yield (kgm^{-2})			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	0.47 c	0.54 bc	0.53 bc	0.51 b
1- week	0.6 abc	0.79 ab	0.45 c	0.61ab
2- week	0.87 a	0.6 abc	0.81 ab	0.76 a
3- week	0.78 ab	0.46 c	0.56 bc	0.6 ab
Mean cultivars	0.68 a	0.6 a	0.59 a	

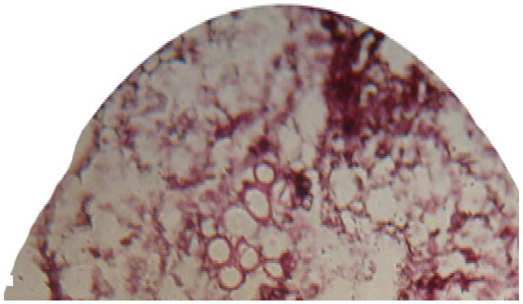
Numbers followed by the same letters in the same column are significantly not different according to Duncan's multiple range tests at 0.05 levels.

3.3.2 Cultivar responses

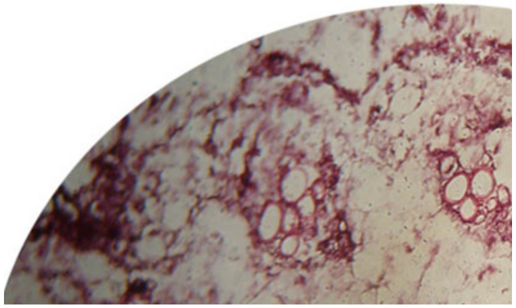
Noura watermelon cultivar (Table 6) showed superiority over Glorry and Charlee in number of stomata in 1 mm^2 (10.2% and 9.8%, respectively), widest vessel (13.1% and 20.5%, respectively) and number of vessels (7.9% and 9.9%. On the other hand Charlee cultivar appeared to come next in the order, as it exceeded Glory cultivar in the length of the second trichome cell (39.7%). Thus, Glorry cultivar manifested the worst response. Water stress imparts much morphological alteration at the level of anatomical context; however, the best drought resistant cultivar should manifest the lower alterations in order to sustain higher functioning organ organelles as well in contrary, susceptible cultivar exhibited higher anatomical alteration levels. Therefore changes in leaf anatomical characteristics can alter the CO_2 conductance diffusion components from the sub stomata cavities to sites of carboxylation and thus contribute to maintenance of photosynthetic rates despite the low stomata conductance (Evans et al., 1994). Albeit, a decline in the photosynthetic rate under water stress conditions could be attributed either to a decrease in stomata conductance and/or to non-stomata limitations (Jones, 1992 and Cornic and Massacci, 1996).

3.3.3 Cultivar responses to flooding

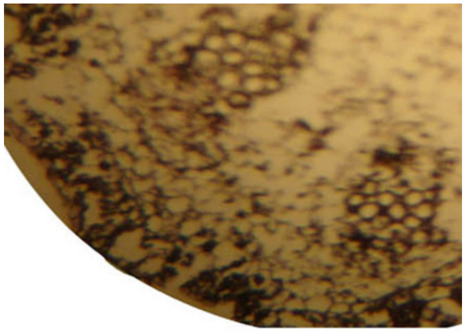
Noura water melon cultivar grown on unflooded land (Table 6 and Figure 4) appeared to be the paramount interaction treatments. This interaction treatment gave the highest stomata length (6 µm), stomata width (5 micron), length of stomata aperture (3.5 µm and vessel number (81). On the other hand Glorry water melon grown on unflooded check was the worst interaction treatment, as it showed the lowest in the length and width of second trichome cell (20 and 11 micron, respectively). The obtained results are in agreements with the results reported by Abdel and Al-Salem (2010). They found that irrigating cowpea plants whenever 25% of soil available water capacity is depleted profoundly exceeded the other two irrigation levels 50 and 75% in terms of stomata lengths of leaf upper surface (20.2 and 41.5%, respectively), stomata lengths of leaf lower surface (13.4 and 36.2%, respectively), lengths stomata aperture at leaf upper surface (25.4 and 62.5%, respectively), lengths of stomata aperture at leaf lower surface (21.1 and 55%, respectively), stomata widths at leaf lower surface (20.2 and 56%, respectively), widths of stomata aperture at leaf upper surface (41.5 and 141.2%, respectively), stomata widths at leaf lower surface (42.3 and 131.8%, respectively). Moreover, 25% level significantly reduced stomata populations at leaf upper surface (24.8 and 53.4%, respectively) and at leaf lower surface (21.2 and 64.9%, respectively), as compared to 50 and 75% irrigation levels. Maximum and minimum stomata resistances were 3.195 and 1.447 S/cm in irrigation after 210 and 70 mm evaporation, respectively. Stomata resistance increased with ABA production enhancement as a result of turgor pressure decrease in water stress condition is the reason of this fact. Stomata resistance also increased with gradual decrease in stomata size. If one leaf is exposed to water deficit condition, the moisture of subsidiary cells will decrease, and consequently stomata diameter, leaf area and relative water content decrease and stomata resistance increase, which resulted in decrease of seed yield. The above results are in agreement with those obtained by Mojayad and planchon (1998) Lahlou et al. (2003), and Khalilv and Yarnia (2007)..



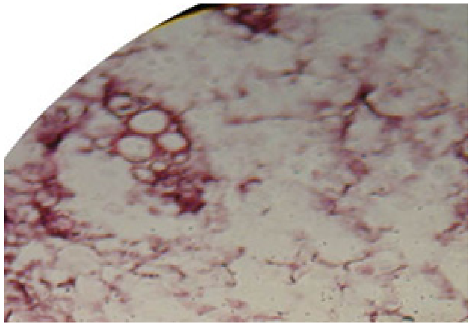
Control – Rainfalls - no flooding



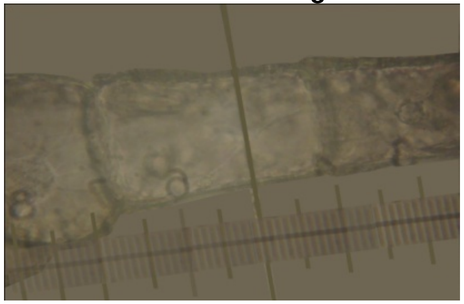
One week flooding land



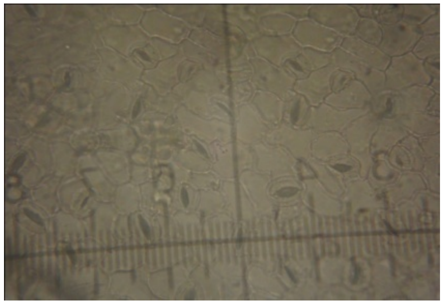
Two weeks flooding land



Three weeks flooding land

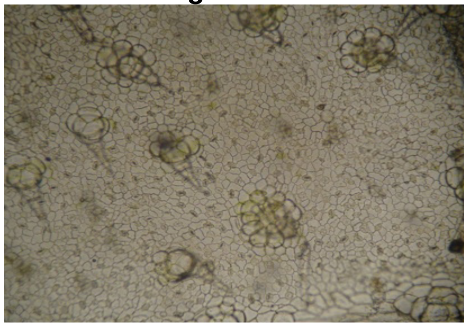


Graded lens to measure trichome hair

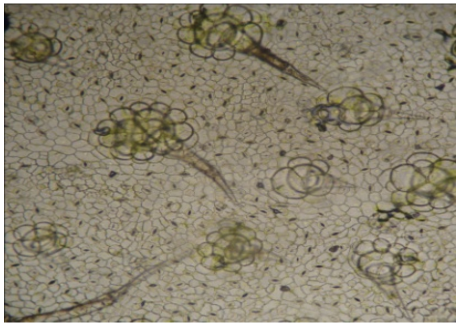


Graded lens for stomata dimensions

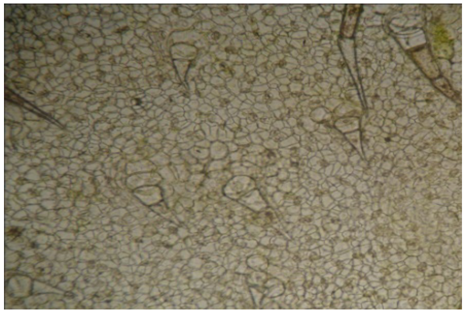
cells each graded = 0.9 micron measurements



Glory watermelon cultivar grown on 1 week flooded land 1mm^2



Noura watermelon cultivar grown on 1 week flooded land 1mm^2



Charlee watermelon cultivar grown on 3 week flooded land 1mm^2

Fig. 4. Leaf petiole cross section of watermelon Glory cultivars

Table 6. Responses of Noura, Glory and Charlee watermelon cultivars to varying land flooding period before planting in terms of some anatomical traits

Treatments	Varieties			
	Cuticle thickness (micron)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	1.25a	1.625a	1.625 a	1.5a
1- week	1.62a	1.5a	1.5 a	1.54a
2- week	1.37a	1.75a	1.12 a	1.41a
3- week	1.75a	1.37a	1.5a	1.54a
Mean cultivars	1.5a	1.56a	1.44a	
	Stomata length (micron)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	6a	5.5abc	5.25abc	5.58a
1- week	5.5 abc	5.5abc	5bc	5.33a
2- week	5.5abc	4.75c	5.25abc	5.13a
3- week	5bc	5.75ab	5.25abc	5.16a
Mean cultivars	5.5a	5.38a	5.19a	
	Stomata width (micron)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	5 a	4.5a	3.75a	4.41a
1- week	4.25a	4.25a	4.25a	4.25a
2- week	4.25a	4.5a	3.75a	4.25a
3- week	4a	4.25 a	4.5a	4.16a
Mean cultivars	4.37a	4.37 a	4.06a	
	Length of stomata aperture (micron)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	3.5a	2.75ab	3ab	3.08a
1- week	2.75 ab	2 b	3.ab	2.75a
2- week	2.75 ab	3.5a	2b	2.75a
3- week	3 ab	2.5 ab	2.75ab	2.75a
Mean cultivars	3a	2.81a	2.69a	
	Width of stomata aperture (micron)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	1.62a	1.25a	1.25a	1.37a

1- week	1a	1.12a	0.75a	0.95a
2- week	0.75a	1.62a	0.87a	1.08a
3- week	0.87a	0.75a	1.12a	0.91a
Mean cultivars	1.06a	1.18a	1a	
	Number of stomata at 1 mm^2 in upper leaf surface			
Control	**Noura**	**Glory**	**Charlee**	**Mean Irrigation**
	171.75cd	174.75cd	172.5cd	173b
1- week	205abc	186.75abcd	184.5bcd	192.33ab
2- week	216.25ab	178.75cd	218.75ab	204.58a
3- week	220a	197.25abcd	164.75d	194ab
Mean cultivars	203.25a	184.38b	185.13b	
	Number of cells at 1 mm^2 in upper leaf surface			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	282.5d	601.75cd	645.5bcd	609.92b
1- week	701.25abcd	727.25abcd	680.75abcd	703.0a
2- week	819.5a	682.5abcd	773ab	758.33a
3- week	804.5ab	750.5abc	583.75d	712.92a
Mean cultivars	726.94a	690.5a	670.75a	
	Number of cell trichome hair			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	6.25 a	7 a	5.75a	6.33a
1- week	5.5 a	6.25 a	6a	5.91a
2- week	6.75a	6 a	6.25a	6.32a
3- week	7a	6a	5.75a	6.25a
Mean cultivars	6.37a	6.31a	5.93a	
	Length of second cell in trichome hair (micron)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	32.75ab	20b	48.75a	33.83a
1- week	42.25ab	26ab	28.5ab	32.25a
2- week	35ab	51.75a	51.75a	45.16a
3- week	38.25ab	29.25ab	48.5a	38.66a
Mean cultivars	37.66ab	31.75b	44.37a	
	Width of second cell in trichome hair (micron)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	16.25bc	11c	17.25bc	15b

1- week	17.25bc	14.25bc	25.75ab	19.08ab
2- week	21.25ab	32.75a	18bc	24.66a
3- week	18.25bc	14.25bc	19bc	17.16b
Mean cultivars	18.75a	18.18a	20a	
		Leaf potential (bars)		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	8a	8a	7.75a	7. 91a
1- week	8a	8a	8a	8a
2- week	8a	7.75a	8a	7 .91a
3- week	7.75a	8a	8a	7.91a
Mean cultivars	7.94a	7.94a	7.94a	
		Widest diameter of xylem vessels (micron)		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	10ab	9.25ab	7b	8.75ab
1- week	9ab	6.75ab	9ab	8.25b
2- week	11a	8.5ab	8.25ab	9.25a
3- week	9.5ab	9ab	8.5ab	9AB
Mean cultivars	9.87a	8.37b	8.19b	
		Narrowest diameter of xylem vessels (micron)		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	3.25ab	3b	3.13b	3.12b
1- week	3b	3.5ab	3b	3.16b
2- week	4.13a	3.75ab	4.25a	4.04a
3- week	3.75ab	4a	3b	3.58ab
Mean cultivars	3.53a	3.56a	3.34a	
		Number of xylem vessels		
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	81 a	67 ab	71 ab	73 ab
1- week	74 ab	71 ab	65 b	70 ab
2- week	76 ab	74 ab	72 ab	74 a
3- week	69 ab	66 b	65 b	66.6 b
Mean cultivars	75 a	69.5 b	68.25 b	

**Numbers followed by the same letters in the same column are significantly not different according to Duncan's multiple range test at 0.05 levels.*

Lovisolo and Schubert (1998) fond that vessels of water stressed plants had lower areas. Reduced development of xylem vessels in grapevine subjected to moderate water stress were attributed to the control of water flow and to a reduction in vulnerability to xylem embolism. They also found that shoot hydraulic conductivity (k_h), shoot specific conductivity (k_s) and leaf specific conductivity (k_l) were lower in water stressed plants. When conductivities were measured on shoot portions, differences between treatments were particularly high at the basal internodes. They also reported that at the lower stress level no embolism was detected, and reduced conductivity could be explained by the reduction of vessel diameter. However, at the higher stress level k_h was further reduced by formation of vessel embolisms.

3.4 Chlorophyll Content and Total Soluble Solids (TSS)

The obtained results (Table 7) manifested that treatment of land flooding for 3 weeks before planting was the most potent treatment. It exceeded that of control treatment in total sugar (38.8%) and TSS (33.16%). Nevertheless, insignificant differences neither among other flooding treatments nor between cultivars were detected in all studied parameters relevant to growth performance of watermelon. Charlee cultivar planted on 3 weeks flooded land seems to be the superior treatment, since it manifested the highest values in most detected characteristics. It exceeded Noura cultivar control which was the inferior treatment in terms of total sugar content of edible flesh (69.42%) and total soluble solids (58.6%).

Table 7. Responses of Noura, Glory and Charlee watermelon cultivars to varying land flooding period before planting in terms of sugar, chlorophyll contents and TSS

Treatments	Varieties			
	Total Sugar Content of Edible Fruit Flesh (%)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	5.69b	6.97 ab	5.69 b	6.11b
1- week	6.73 ab	6.62 ab	7.07 ab	6.81 ab
2- week	7.43 ab	6.62 ab	9.21 ab	7.75 ab
3- week	7.55 ab	8.25 ab	9.64 a	8.48 a
Mean cultivars	6.85 a	7.12 a	7.90 a	
	Total Soluble Solids percentages of Fruit Flesh (TSS)			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	7.25 b	8.62 ab	7.25 b	7.7 b
1- week	8.37 ab	8.25 ab	9 ab	8.54 ab
2- week	9.125 ab	85.25 ab	11.125 ab	9.5 ab
3- week	9.25 ab	10 ab	11.5 a	10.25 a
Mean cultivars	8.50 a	8.78 a	9.72 a	
	Leaves Chlorophyll Content			
	Noura	**Glory**	**Charlee**	**Mean irrigation**
Control	63.65 a	59.48 a	65.48 a	62.87 a
1- week	60.83 a	57.23 a	63.55 a	60.53 a
2- week	64.95 a	57.45 a	67.43 a	63.28 a
3- week	61.53 a	58.4 a	64.58 a	61.50 a
Mean cultivars	62.75 a	57.14 a	65.26 a	

**Numbers followed by the same letters in the same column are significantly not different according to Duncan's multiple range test at 0.05 levels.*

The reasons why non-significant differences were detected are that all flooding treatments exhibited low moisture content at the root zone, and thus watermelon plants experienced severe drought and these conditions were confirmed from gypsum block reading, where no differences were detected. Moreover, during July and August where high temperature and light intensities synchronized drought the diversity was aggravated and resulted on growth casements. However, growth was resumed when temperature and light intensity being increasingly suitable for growth (Table 3).

4. CONCLUSION

It can be concluded from the present study that Charlee was the worst responded cultivar and the order according to cultivar capabilities in drought resistance are as the following. Noura > Glory > Charlee. The best dual interaction treatment was growing Noura cultivar on land flooded for 2week with water height of 10cm which manifested superiority over other treatments. Since it gave the highest (plant length (215cm), leaf dry matter percentage (22.13), fruit length (26 cm), yield (0.87 kgm-2), number of stomata in 1 mm2 (220), number of cells in 1 mm2 (819.5) and widest diameter of xylem vessels (11micron).

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