Journal of Agricultural Science and Technology (2025) Vol. 27 (4): 775-790

Changes in Some Seedling Growth Parameters, Nutrient Content and Enzyme Activity in Different Melon (*Cucumis melo* L.) Genotypes under Deficit Irrigation Conditions

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ABSTRACT

Increasing need for drought adaptation measures to conserve water and sustain crop yield in water-scarce regions is driven by severe and recurrent droughts. Achieving sustainable production entails studying deficit irrigation as a means to enhance water productivity and selecting genotypes resilient to soil water deficits. In the present study, 17 different melon (*Cucumis melo* L.) genotypes collected from the Van Lake Basin and 3 hybrids and 1 standard melon cultivar for control purposes were used for this purpose. The study was carried out under climate room conditions. Two different irrigation levels (I_{100}: 100% full irrigation, I_{50}: 50% Deficit Irrigation- DI) were applied in the study for deficit irrigation. Water applications started with the emergence of the second true leaf of the plants and, after one-month, different growth, nutrient, and enzyme contents of the seedlings were determined. In general, it was determined that deficit water application negatively affected seedling growth, and root dry matter, stomatal opening and density, potassium, APX and SOD enzymes, and MDA content increased, while the other tested parameters decreased. The melon genotypes of the Van Lake Basin were found to vary in response to deficit irrigation treatments.

Keywords: Antioxidative response, Mineral composition, Van Lake Basin melon.

INTRODUCTION

Melon (*Cucumis melo* L.), renowned for its rich nutritional profile, originates from East Africa (Pitrat, 2008). Global melon production, totaling around 32 million tons, sees China (PRC) as the leading contributor, accounting for 40%, while Turkey follows closely with approximately 5.5% (FAO, 2019). Turkey, a recognized gene center for various crops including melon, stands as a secondary gene center for this species (Sensoy *et al*., 2007a; Erdinc *et al*., 2013; Kısaca and Gazioglu Sensoy, 2023). The Van Province in Eastern Anatolia, Turkey, holds significance as one of the origins of cantaloupe melon (Sensoy *et al*., 2007a; Turkmen *et al*., 2008). Genetic studies by Sensoy and Sahin (2012) revealed a notably high genetic diversity among Sihke melon genotypes in the Lake Van Basin.

Drought, a prominent abiotic stress, significantly jeopardizes global agricultural yield and quality. With the escalation of global warming-induced climate change, arid and semi-arid regions face exacerbated drought challenges (Tan *et al*., 2006; Pandey *et al*., 2018). Under drought conditions, plant growth and development are impeded

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due to slow cell division, interrupted transpiration, and inhibited nutrient uptake, leading to diminished productivity (Sensoy *et al*., 2007b; Farooq *et al*., 2009; Cakmakci *et al*., 2017). In areas heavily reliant on agriculture, optimizing water resource utilization is imperative to alleviate the adverse impacts of climate change.

To address future challenges arising from climate change and a growing global population, it is crucial to develop drought-tolerant plant genotypes requiring less water. In Turkey, insufficient precipitation has led to significant agricultural losses, emphasizing the urgent need to identify and select drought-tolerant genotypes through expanded breeding programs (Kabay and Sensoy, 2016). Melon, a globally cultivated fruit with high nutritional and economic value, faces water scarcity issues, particularly in arid regions. Deficit Irrigation (DI), a water-saving strategy, seeks to enhance water use efficiency while sustaining plant growth. Numerous studies have explored the impact of DI on melon growth parameters across different genotypes (Sensoy *et al*. 2007b; Kusvuran *et al*., 2011; Sharma *et al*., 2014; Kırnak and Dogan, 2017; Wang *et al*., 2017; Barzegar *et al*., 2018; Lamaoui *et al*., 2018).

Understanding the genetic variability and inheritance of physiological traits under DI is vital. This study focuses on evaluating melon genotypes from the Van Lake Basin for their response to water deficit during the seedling stage, utilizing morphological and physiological parameters to identify tolerant genotypes for future breeding programs.

MATERIALS AND METHODS

Sihke melon genotypes sourced from the Van Lake Basin, alongside three hybrids and a standard cultivar for control (Table 1), constituted the plant materials for this study. Under room conditions (16 hours light, 8 hours dark, 50-55% humidity and 23-25°C), seeds of the genotypes were sown in 2-liter pots containing a sterile 2:1 peat to perlite ratio. The experiment featured two irrigation levels: I_{100} (100% full irrigation) and I_{50} (50% deficit irrigation). The study consisted of a two-factor factorial design (melon

Table 1. Melon genotypes used in the study.

Genotype	Provided Location information	Latitude (N)	Latitude (E)	Genotype	Provided location information	Latitude (N)	Latitude (E)
YYU-1	Van-Sihke-Kiratli	38° 31' 57.9504"	43° 27' 47.3688"	YYU-21	Van-Unseli	38°59'6"	43° 35' 16"
YYU-4	Van-Sihke-Kiratli	38° 31' 57.9504"	43° 27' 47.3688"	YYU-22	Van-Ercis	39° 1′ 52″	43° 21′ 35″
YYU-6	Van-Sihke-Kiratli	38° 31' 57.9504"	43° 27' 47.3688"	YYU-23	Van-Ercek-Irgatli	38° 36' 38,0628"	43° 36' 52.4766"
YYU-10	Van-Sihke	38°32'1"	43° 25' 20"	YYU-25	Van-Ercek-Irgatli	38° 36' 38.0628"	43° 36' 52.4766"
YYU-11	Van-Sihke-Kiratli	38° 31' 57.9504"	43° 27' 47.3688"	YYU-29	Van-Ercek-Irgatli	38° 36' 38.0628"	43° 36' 52.4766"
YYU-12	Van-Sihke-Kiratli	38° 31' 57.9504"	43° 27' 47.3688"	YYU-30	Van-Ercek-Irgatli	38° 36' 38.0628"	43° 36' 52.4766"
YYU-13	Van-Sihke-Kiratli	38° 31' 57.9504"	43° 27' 47.3688"	Galia	Standard		
YYU-14	Van-Sihke-Kiratli	38° 31' 57.9504"	43° 27' 47.3688"	Kirkagac F_1	Yüksel Tohum		
YYU-15	Van-Sihke-Kiratli	38° 31' 57.9504"	43° 27' 47.3688"	Lokum F_1	Yüksel Tohum		
YYU-18	Van-Cakirbey	39° 9' 15.2064"	43° 21' 35.6868"	Napolyon F_1	Yüksel Tohum		
YYU-20	Van-Unseli	38° 59' 6"	43° 35' 16"				

genotype and irrigation). Employing a randomized experimental design with three replications, each replication (total of 126 pots) had four plants. The initiation of applications coincided with the emergence of the second true leaves of the seedlings.

A and B solutions, comprising nutrients (A solutions:10.03% N, 1.6% NH_4-N, 8.7% NO_3-N, 7.5% K_2O, 8.6% Ca, 0.3 % Fe and B solution; 2.1% N, 2.1% NO_3-N, 6.4% P_2O_5, 11.6% K_2O, 1.6% Mg, 0.01% Zn, 0.003% Cu, 0.1% Mn, 0.003% B, 0.004% Mo), were administered (50 mL) to all pots. Pre-planned irrigations followed, with water applied to reach field capacity before each irrigation cycle, determined by the pot capacity. The irrigation water volume for each session was computed using the following equation:

$$\mathrm{I} = (\mathrm{Wi} - 1 - \mathrm{Wi}) \times \mathrm{IR}$$

Where, I is the amount of Irrigation water (mL), W_{i-1} and W_i mass (kg) of the pot at day i–1 and i, respectively (kg). IR is the Irrigation levels (I_{100}: %100, full irrigation; I_{50}: %50 deficit irrigation).

The plants were hand-watered with tap water and the trial was terminated 30 days after sowing (Kadayifci *et al*., 2005).

Seedling Growth Parameters

Upon completing the experiment, various seedling growth parameters were assessed, encompassing shoot and root lengths, shoot diameter, leaf count, Shoot and Root Fresh Weights (SFW and RFW), Shoot and Root Dry Weights (SDW and RDW), Shoot and Root Dry Matter (SDM and RDM) quantities, and the Root-to-Shoot ratio (dry weight %) denoted as R/S. Fresh weights of roots and stems were measured on a precision scale and recorded as SFW and RFW, and the same samples were kept in an oven at 65 °C for 48 hours and their dry weights were recorded as SDW and RDW. Stem and root dry matter ratios were calculated as percentages and recorded as SDM and RDM. Additionally, the genotypes' responses to deficit irrigation were evaluated on a 0-5 scale, with 0 signifying no effect (akin to control plants) and 5 indicating severe wilting and drying in leaves (Cakmakci *et al*., 2017).

Stomatal Traits

Stomatal traits, including stomatal density (units per mm^2), stomatal area (μm^2), and stomatal width and length (µm), were determined using the lower epidermis of the 4^{th} leaf of the plants. The epidermis was carefully peeled and mounted on a slide with two water droplets (Kurtar *et al*., 2016). Stoma quantification was conducted using the LAS EZ 3.0 program, examining tissue samples on the slide at 40X magnification under a light microscope (LEICA DM500). Three randomly selected areas of 0.08 mm^2 were analyzed for accurate assessment.

Mineral Matter Content

Macro-micro nutrient content in plant leaves was determined by the dry combustion method (Kacar and Inal, 2010). Plant leaf samples underwent a 48-hour drying process at 65ºC, followed by crushing with a porcelain mortar. Subsequently, 0.5 grams of the dry samples were ashed at 550ºC. The resulting ash was dissolved in 3N HCl. Potassium (K), Calcium (Ca), Magnesium (Mg), iron (Fe), Zinc (Zn), Copper (Cu), and Manganese (Mn) levels were quantified using an atomic absorption spectrophotometer, while Phosphorus (P) content was determined using a spectrophotometer.

Enzyme Activation

Superoxide Dismutase (SOD) activity was assessed by inhibiting Nitro Blue Tetrazolium (NBT) at 560 nm (Jebara *et al*., 2005). SOD activity was quantified as the unit reducing 50% of NBT. Catalase (CAT) activity was determined by monitoring H_2O_2

disappearance at 240 nm, following Cakmak and Marschner's method (1992). Ascorbate Peroxidase (APX) activity was measured by reducing H_2O_2 bound to ascorbic acid at 290 nm, with APX activity defined as the enzyme amount needed to consume 1 µmol of ascorbate per minute (Cakmak and Marschner, 1992).

Lipid Peroxidation (MDA)

Lipid Peroxidation (MDA) was determined by the method of Heath and Packer (1968). The absorbance value of the mixture was determined at 532 and 600 nm wavelengths and the MDA content was calculated with a molar absorption coefficient of 155 mM cm^{-1}.

Statistical Evaluation

Data from the study were statistically analyzed using the SPSS program, applying analysis of variance with a significance level of P≤ 0.05. Significant mean differences were further categorized using Duncan's Multiple Comparison Test. The XLSTAT statistical program, along with Principal Component Analysis (PCA) as a multivariate data analysis method, was employed to discern and emphasize similarities or differences resulting from the study's applications and examined features. The extent to which these differences were explained was also determined.

RESULTS

Seedling Growth

Table 2 summarizes significant variations in leaf number, shoot diameter, and shoot/root lengths among melon genotypes subjected to full and deficit irrigation. Overall, deficit irrigation resulted in reduced leaf numbers across all genotypes, with YYU25 and YYU13 exhibiting the highest (8.25) and lowest (4.38) values under full irrigation. Stem diameter showed

Table 2. Seedling growth parameters in melon genotypes under full (I_{100}) and deficit (I_{50}) irrigation levels.[a]

Genotype	Leaf number		Stem diameter (mm)		Shoot length (cm)		Root length (cm)	
	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}
YYU1	$5.50_{\pm0.43}^{b-f}$	$4.36_{\pm0.13}^{b-e}$	$5.00_{\pm1.92}^{cf}$	$3.93_{\pm5.28}^{d-g}$	$41.88_{\pm1.92}^{b-d}$	$29.51_{\pm5.28}^{b-e}$	$21.08_{\pm3.47}$	$17.69_{\pm0.72}$
YYU4	$5.50_{\pm0.43}^{b-f}$	$3.50_{\pm0.25}^{e-g}$	$5.39_{\pm6.57}^{be}$	$4.50_{\pm4.35}^{b-f}$	$44.58_{\pm6.57}^{b-d}$	$28.54_{\pm4.35}^{b-e}$	$18.38_{\pm1.85}$	$14.47_{\pm1.53}$
YYU6	$5.64_{\pm0.13}^{b-f}$	$4.08_{\pm0.29}^{c-f}$	$5.19_{\pm7.37}^{cf}$	$4.40_{\pm2.64}^{b-f}$	$38.69_{\pm7.37}^{b-d}$	$25.21_{\pm2.64}^{b-f}$	$20.75_{\pm2.54}$	$15.75_{\pm3.45}$
YYU10	$5.33_{\pm0.63}^{c-f}$	$4.08_{\pm0.80}^{c-f}$	$5.45_{\pm5.34}^{bd}$	$4.31_{\pm7.06}^{c-g}$	$33.51_{\pm5.34}^{b-d}$	$25.23_{\pm7.06}^{b-f}$	$16.67_{\pm2.80}$	$14.88_{\pm1.44}$
YYU11	$4.83_{\pm0.29}^{d-f}$	$3.64_{\pm0.13}^{d-g}$	$6.67_{\pm4.21}^{a}$	$5.52_{\pm3.58}^{a}$	$29.79_{\pm4.21}^{cd}$	$21.08_{\pm3.58}^{d-f}$	$23.11_{\pm3.78}$	$17.65_{\pm0.67}$
YYU12	$4.56_{\pm0.55}^{ef}$	$3.00_{\pm0.00}^{fg}$	$5.89_{\pm3.52}^{ac}$	$4.69_{\pm1.35}^{a-e}$	$30.83_{\pm4.07}^{cd}$	$17.88_{\pm1.35}^{ef}$	$19.00_{\pm0.99}$	$18.04_{\pm1.28}$
YYU13	$4.38_{\pm0.57}^{f}$	$4.39_{\pm1.40}^{b-e}$	$6.45_{\pm4.05}^{ab}$	$5.19_{\pm2.77}^{a-c}$	$30.25_{\pm2.88}^{cd}$	$19.29_{\pm2.77}^{ef}$	$20.04_{\pm4.33}$	$18.28_{\pm5.00}$
YYU14	$5.47_{\pm1.63}^{b-f}$	$2.97_{\pm0.61}^{g}$	$6.28_{\pm8.50}^{ab}$	$5.67_{\pm0.75}^{a}$	$27.69_{\pm6.46}^{d}$	$15.7_{\pm0.75}^{f}$	$20.94_{\pm4.16}$	$20.97_{\pm3.26}$
YYU15	$5.50_{\pm1.06}^{b-f}$	$4.67_{\pm0.76}^{a-e}$	$5.18_{\pm10.34}^{cf}$	$5.39_{\pm3.50}^{ab}$	$36.63_{\pm9.16}^{b-d}$	$23.00_{\pm3.50}^{c-f}$	$21.81_{\pm4.51}$	$17.97_{\pm3.39}$
YYU18	$8.17_{\pm2.04}^{a}$	$4.25_{\pm0.25}^{b-e}$	$4.95_{\pm10.13}^{f}$	$4.45_{\pm3.86}^{b-f}$	$36.00_{\pm0.75}^{b-d}$	$24.96_{\pm3.63}^{b-f}$	$18.96_{\pm3.71}$	$17.92_{\pm1.23}$
YYU20	$6.67_{\pm0.38}^{a-e}$	$4.75_{\pm0.43}^{a-d}$	$5.14_{\pm7.56}^{cf}$	$4.12_{\pm7.63}^{d-g}$	$52.17_{\pm10.13}^{ac}$	$24.79_{\pm3.86}^{b-f}$	$17.63_{\pm2.13}$	$17.96_{\pm4.12}$
YYU21	$7.31_{\pm2.08}^{ac}$	$4.28_{\pm0.05}^{b-e}$	$5.12_{\pm17.38}^{f}$	$4.91_{\pm3.06}^{a-d}$	$47.08_{\pm7.56}^{a-d}$	$34.75_{\pm7.63}^{bc}$	$16.79_{\pm3.73}$	$18.51_{\pm3.45}$
YYU22	$7.64_{\pm1.76}^{ab}$	$4.53_{\pm0.94}^{b-e}$	$4.98_{\pm15.02}^{cf}$	$4.52_{\pm8.26}^{b-f}$	$55.75_{\pm17.38}^{ab}$	$33.13_{\pm3.06}^{b-d}$	$21.75_{\pm3.85}$	$18.51_{\pm2.61}$
YYU23	$7.67_{\pm0.29}^{ab}$	$4.67_{\pm0.38}^{a-e}$	$4.57_{\pm8.72}^{dg}$	$3.74_{\pm7.12}^{e-g}$	$48.04_{\pm15.02}^{ad}$	$27.46_{\pm8.26}^{b-f}$	$16.76_{\pm2.56}$	$14.90_{\pm0.57}$
YYU25	$8.25_{\pm1.34}^{a}$	$5.78_{\pm0.46}^{a}$	$4.17_{\pm20.82}^{fg}$	$3.61_{\pm16.25}^{fg}$	$52.79_{\pm8.72}^{a-c}$	$36.79_{\pm7.12}^{ab}$	$18.17_{\pm2.89}$	$15.20_{\pm1.92}$
YYU29	$5.75_{\pm1.30}^{b-f}$	$4.25_{\pm0.75}^{b-e}$	$4.40_{\pm21.41}^{bg}$	$3.80_{\pm7.50}^{e-g}$	$68.75_{\pm20.82}^{a}$	$46.24_{\pm16.25}^{a}$	$15.29_{\pm1.12}$	$18.42_{\pm0.59}$
YYU30	$5.33_{\pm1.28}^{c-f}$	$4.75_{\pm0.90}^{a-d}$	$2.71_{\pm10.26}^{h}$	$2.18_{\pm4.88}^{h}$	$39.17_{\pm21.41}^{bd}$	$33.58_{\pm7.50}^{bc}$	$17.94_{\pm3.77}$	$16.45_{\pm0.51}$
Galia	$6.47_{\pm0.21}^{a-f}$	$5.29_{\pm0.25}^{ab}$	$4.62_{\pm0.75}^{dg}$	$4.77_{\pm3.63}^{a-e}$	$31.58_{\pm10.26}^{cd}$	$34.82_{\pm4.88}^{bc}$	$18.58_{\pm3.00}$	$20.38_{\pm2.26}$
Kirkagac	$6.14_{\pm1.32}^{a-f}$	$4.50_{\pm0.43}^{b-e}$	$4.30_{\pm24.19}^{eg}$	$3.83_{\pm5.03}^{e-g}$	$44.64_{\pm24.19}^{bd}$	$32.92_{\pm5.03}^{b-d}$	$17.21_{\pm3.05}$	$21.40_{\pm8.64}$
Lokum	$6.22_{\pm1.28}^{a-f}$	$5.00_{\pm0.66}^{a-c}$	$3.63_{\pm14.44}^{gh}$	$3.29_{\pm3.31}^{g}$	$32.19_{\pm14.44}^{cd}$	$33.25_{\pm3.31}^{b-d}$	$13.79_{\pm6.29}$	$15.54_{\pm1.91}$
Napolyon	$7.00_{\pm1.56}^{ad}$	$4.50_{\pm0.43}^{b-e}$	$4.43_{\pm6.25}^{dg}$	$3.95_{\pm8.82}^{d-g}$	$68.75_{\pm6.25}^{a}$	$29.78_{\pm8.82}$ b-e	$17.50_{\pm0.76}$	$16.25_{\pm0.78}$
*p-value	0.001	0.000	0.001	0.000	0.001	0.000	0.152	0.247

[a] I_{100}: Full Irrigation, I_{50}: 50% Deficit Irrigation. *: Significant distinctions among groups were observed at the P< 0.05 level, as determined by Duncan's multiple comparison test.

considerable diversity, ranging from 6.67 mm (YYU11) to 2.71 mm (YYU30). Full irrigation promoted longer shoot lengths in YYU30 and cv. Napolyon (67.75 cm) and shorter lengths in YYU30 (27.69 cm). Root lengths displayed variability, with certain genotypes displaying resilience to full irrigation.

Under deficit irrigation, the number of leaves declined, particularly in YYU25 (5.78) and YYU14 (2.97). Stem diameter ranged from 5.67 mm (YYU14) to 2.18 mm (YYU30). Shoot lengths were longest in YYU29 (46.24 cm) and shortest in YYU14 (15.75 cm). Most genotypes experienced reductions in shoot and root lengths, indicating diverse responses to deficit irrigation.

Table 3 illustrates significant variations in parameters among genotypes and cultivars under full irrigation, excluding RDW. YYU14 displayed the highest SFW in full irrigation (22.06 g), while YYU30 had the lowest (4.34 g). Under deficit irrigation, YYU15 recorded the highest SFW (13.05 g), and YYU30 had the lowest (3.50 g). SDW responded positively to stress in YYU29 and YYU30, while other genotypes showed negative effects. In full irrigation, YYU18 exhibited the highest SDW (1.35 g), and YYU30 showed the lowest (0.39 g). Under deficit irrigation, YYU13 and YYU15 displayed the highest SDW (0.88 g and 0.86 g, respectively), while YYU30 had the lowest (0.40 g). For RFW, all genotypes experienced a decrease under stress, while RDW increased in four genotypes and three cultivars. YYU15 demonstrated the highest RFW in full irrigation (1.59 g), and YYU30 had the lowest (0.49 g). Under deficit irrigation, YYU14 recorded the highest RFW (0.98 g), with YYU30 displaying the lowest (0.31 g). In deficit irrigation, the highest RDW was in YYU12 (0.083 g),

Table 3. Seedling growth traits variation in melon genotypes under full (I_{100}) and deficit (I_{50}) irrigation levels: Selected values and standard deviations.[a]

Genotype	Shoot fresh weight (g)		Shoot dry weight (g)		Root fresh weight (g)		Root dry weight (g)	
	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}
YYU1	$15.99_{\pm 1.05}^{b-d}$	$9.87_{\pm 2.83}^{b-d}$	$0.80_{\pm 0.11}^{b-e}$	$0.55_{\pm 0.18}^{b-d}$	$0.89_{\pm 0.13}^{b-e}$	$0.62_{\pm 0.21}^{a-e}$	$0.044_{\pm 0.004}$	$0.053_{\pm 0.015}^{a-f}$
YYU4	$14.73_{\pm 0.23}^{b-e}$	$8.41_{\pm 0.47}^{b-f}$	$0.99_{\pm 0.13}^{a-c}$	$0.63_{\pm 0.08}^{a-d}$	$0.89_{\pm 0.11}^{b-e}$	$0.53_{\pm 0.14}^{b-e}$	$0.056_{\pm 0.005}$	$0.043_{\pm 0.009}^{b-f}$
YYU6	$12.23_{\pm 1.59}^{c-f}$	$6.82_{\pm 1.30}^{d-f}$	$0.72_{\pm 0.13}^{c-e}$	$0.53_{\pm 0.12}^{b-d}$	$1.04_{\pm 0.55}^{a-e}$	$0.48_{\pm 0.15}^{c-e}$	$0.056_{\pm 0.028}$	$0.037_{\pm 0.008}^{c-f}$
YYU10	$15.36_{\pm 1.40}^{b-e}$	$7.32_{\pm 2.00}^{a-f}$	$0.97_{\pm 0.10}^{a-c}$	$0.54_{\pm 0.18}^{b-d}$	$0.81_{\pm 0.18}^{b-e}$	$0.52_{\pm 0.15}^{b-e}$	$0.051_{\pm 0.012}$	$0.041_{\pm 0.008}^{b-f}$
YYU11	$15.99_{\pm 1.68}^{b-d}$	$10.83_{\pm 0.37}^{ab}$	$1.12_{\pm 0.12}^{a-c}$	$0.74_{\pm 0.09}^{ab}$	$1.14_{\pm 0.17}^{a-e}$	$0.78_{\pm 0.16}^{a-d}$	$0.079_{\pm 0.016}$	$0.073_{\pm 0.005}^{a-c}$
YYU12	$16.81_{\pm 1.34}^{bc}$	$9.29_{\pm 1.11}^{b-e}$	$1.10_{\pm 0.15}^{a-c}$	$0.70_{\pm 0.01}^{a-c}$	$1.28_{\pm 0.14}^{a-d}$	$0.96_{\pm 0.18}^{ab}$	$0.080_{\pm 0.016}$	$0.083_{\pm 0.02}^{a}$
YYU13	$16.79_{\pm 0.55}^{bc}$	$13.01_{\pm 2.32}^{a}$	$0.98_{\pm 0.12}^{a-c}$	$0.88_{\pm 0.10}^{a}$	$1.23_{\pm 0.28}^{a-d}$	$0.88_{\pm 0.20}^{a-c}$	$0.079_{\pm 0.041}$	$0.072_{\pm 0.025}^{a-d}$
YYU14	$22.06_{\pm 6.53}^{a}$	$10.28_{\pm 2.34}^{a-c}$	$1.35_{\pm 0.57}^{a}$	$0.72_{\pm 0.14}^{a-c}$	$1.42_{\pm 0.69}^{ab}$	$0.98_{\pm 0.37}^{a}$	$0.087_{\pm 0.028}$	$0.072_{\pm 0.039}^{a-c}$
YYU15	$15.01_{\pm 5.06}^{b-e}$	$13.05_{\pm 4.16}^{a}$	$0.88_{\pm 0.27}^{b-d}$	$0.86_{\pm 0.25}^{a}$	$1.59_{\pm 0.33}^{a}$	$0.94_{\pm 0.38}^{ab}$	$0.062_{\pm 0.040}$	$0.074_{\pm 0.028}^{ab}$
YYU18	$18.92_{\pm 4.53}^{ab}$	$8.11_{b-f \pm 0.21}$	$1.35_{\pm 0.26}^{a}$	$0.70_{\pm 0.03}^{a-c}$	$1.34_{\pm 0.77}^{a-c}$	$0.76_{\pm 0.16}^{a-d}$	$0.082_{\pm 0.019}$	$0.061_{\pm 0.008}^{a-e}$
YYU20	$15.09_{\pm 2.62}^{b-e}$	$9.67_{\pm 1.86}^{b-d}$	$1.10_{\pm 0.13}^{a-c}$	$0.67_{\pm 0.05}^{a-c}$	$1.17_{\pm 0.32}^{a-d}$	$0.68_{\pm 0.36}^{a-e}$	$0.064_{\pm 0.022}$	$0.045_{\pm 0.005}^{b-f}$
YYU21	$15.74_{\pm 1.86}^{b-e}$	$7.74_{\pm 0.28}^{b-f}$	$1.19_{\pm 0.14}^{ab}$	$0.75_{\pm 0.02}^{ab}$	$1.01_{\pm 0.18}^{a-e}$	$0.60_{\pm 0.08}^{a-e}$	$0.085_{\pm 0.013}$	$0.073_{\pm 0.031}^{ab}$
YYU22	$12.53_{\pm 1.93}^{c-f}$	$7.68_{\pm 1.67}^{b-f}$	$0.89_{\pm 0.23}^{b-d}$	$0.67_{\pm 0.22}^{a-c}$	$0.83_{\pm 0.07}^{b-e}$	$0.73_{\pm 0.37}^{a-e}$	$0.055_{\pm 0.027}$	$0.065_{\pm 0.032}^{a-e}$
YYU23	$11.11_{\pm 2.14}^{d-g}$	$6.12_{\pm 0.33}^{e-g}$	$0.88_{\pm 0.16}^{b-d}$	$0.55_{\pm 0.09}^{b-d}$	$0.81_{\pm 0.13}^{b-e}$	$0.44_{\pm 0.18}^{c-e}$	$0.046_{\pm 0.008}$	$0.036_{\pm 0.008}^{d-f}$
YYU25	$13.19_{\pm 3.98}^{c-f}$	$6.60_{\pm 1.67}^{d-g}$	$0.88_{\pm 0.23}^{b-d}$	$0.54_{\pm 0.12}^{b-d}$	$0.68_{\pm 0.33}^{c-e}$	$0.37_{\pm 0.10}^{de}$	$0.040_{\pm 0.022}$	$0.024_{\pm 0.004}^{f}$
YYU29	$9.07_{\pm 2.96}^{fh}$	$6.57_{\pm 0.74}^{d-g}$	$0.53_{\pm 0.23}^{de}$	$0.54_{\pm 0.05}^{b-d}$	$0.65_{\pm 0.32}^{de}$	$0.40_{\pm 0.15}^{de}$	$0.054_{\pm 0.035}$	$0.037_{\pm 0.008}^{c-f}$
YYU30	$4.34_{\pm 2.32}^{h}$	$3.50_{\pm 0.81}^{g}$	$0.39_{\pm 0.23}^{e}$	$0.40_{\pm 0.14}^{d}$	$0.49_{\pm 0.34}^{e}$	$0.31_{\pm 0.08}^{e}$	$0.048_{\pm 0.023}$	$0.032_{\pm 0.002}^{ef}$
Galia	$11.29_{\pm 1.89}^{d-g}$	$7.53_{\pm 1.43}^{b-f}$	$0.75_{\pm 0.14}^{c-e}$	$0.66_{\pm 0.04}^{a-c}$	$0.76_{\pm 0.25}^{b-e}$	$0.69_{\pm 0.18}^{a-e}$	$0.053_{\pm 0.022}$	$0.054_{\pm 0.008}^{a-f}$
Kirkagac	$10.43_{\pm 0.84}^{e-g}$	$5.48_{\pm 0.82}^{fg}$	$0.99_{\pm 0.22}^{a-c}$	$0.55_{\pm 0.07}^{b-d}$	$0.87_{\pm 0.38}^{b-e}$	$0.55_{\pm 0.21}^{a-e}$	$0.068_{\pm 0.049}$	$0.048_{\pm 0.013}^{a-f}$
Lokum	$6.77_{\pm 1.65}^{gh}$	$6.25_{\pm 0.95}^{e-g}$	$0.55_{\pm 0.28}^{de}$	$0.47_{\pm 0.12}^{cd}$	$0.60_{\pm 0.23}^{de}$	$0.48_{\pm 0.23}^{c-e}$	$0.038_{\pm 0.040}$	$0.034_{\pm 0.014}^{ef}$
Napolyon	$13.14_{\pm 3.42}^{c-f}$	$8.28_{\pm 2.20}^{b-f}$	$0.87_{\pm 0.16}^{b-d}$	$0.67_{\pm 0.23}^{a-c}$	$0.65_{\pm 0.23}^{de}$	$0.60_{\pm 0.28}^{a-e}$	$0.045_{\pm 0.037}$	$0.046_{\pm 0.022}^{b-f}$
*p-value	0.001	0.001	0.001	0.013	0.019	0.008	0.357	0.012

[a] I_{100}: Full Irrigation, I_{50}: 50% Deficit Irrigation. * Significant distinctions among groups were observed at the $P< 0.05$ level, as determined by Duncan's multiple comparison test.

while the lowest was in YYU25 (0.024 g).

Significant variations in SDM content and 0-5 scale values were observed across genotypes and cultivars, with no notable differences in RDM contents and R/S (Table 4). SDM content generally increased with deficit irrigation, with exceptions in YYU11, YYU20, and Lokum. In full irrigation, cv. Kirkagac (9.58%) and genotype YYU30 (8.89%) had the highest SDM, while the lowest was in genotype YYU1 (4.97%). Similarly, in deficit irrigation, YYU30 (11.29%) and cv. Kirkagac (10.12%) showed the highest SDM, and genotype YYU1 (5.57%) had the lowest.

R/S ratio increased with deficit irrigation, except for YYU6, YYU25, YYU29, and YYU30. In full irrigation, genotypes YYU30 (0.142) and cv. Lokum (0.049) had the highest and lowest R/S ratios, respectively. Under deficit irrigation, YYU12 (0.119) and YYU25 (0.050) showed the highest and lowest R/S ratios, respectively. Genotypes YYU10 and YYU12 shared the highest 0-5 scale values (3.333), while cv. Lokum had the lowest (1.667).

Stomatal Traits

Stomatal characteristics in melon genotypes and cultivars significantly differed under full and deficit irrigation (Table 5). Stomatal length and area decreased in 52.38% of cases, while width and density increased by 71.43 and 61.91%, respectively. In full irrigation, genotype YYU22 had the tallest stoma (23.73 µm), and genotype YYU6 had the shortest (8.47 µm). Under deficit irrigation, genotypes YYU25 and YYU22 showed the tallest stomata (21.80 µm and 21.47 µm), and genotype YYU6 had the shortest (14.47 µm). For stoma width, genotype YYU13 had the widest (15.58 µm) in full irrigation, and genotype YYU6 had the narrowest (7.97 µm).

Table 4. Dry matter, root/shoot ratio, and vigor assessment in melon genotypes under full (I_{100}) and deficit (I_{50}) irrigation levels: Mean values and standard deviations.[a]

Genotype	Shoot dry matter content (%)		Root dry matter content (%)		Root: Shoot ratio		0-5 scale
	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}	I_{50}
YYU1	$4.97_{\pm0.40}^{d}$	$5.57_{\pm0.38}^{g}$	$5.11_{\pm1.20}$	$8.88_{\pm2.89}$	$0.056_{\pm0.003}$	$0.102_{\pm0.047}$	$2.333_{\pm1.15}^{a-c}$
YYU4	$6.75_{\pm0.97}^{b-d}$	$7.53_{\pm0.78}^{d-f}$	$6.42_{\pm1.33}$	$8.25_{\pm1.16}$	$0.057_{\pm0.002}$	$0.067_{\pm0.007}$	$2.667_{\pm0.58}^{a-c}$
YYU6	$5.87_{\pm0.65}^{cd}$	$7.69_{\pm0.61}^{d-f}$	$5.55_{\pm1.48}$	$8.00_{\pm2.24}$	$0.077_{\pm0.034}$	$0.072_{\pm0.021}$	$3.000_{\pm0.00}^{ab}$
YYU10	$6.33_{\pm0.12}^{b-d}$	$7.36_{\pm0.46}^{d-f}$	$6.27_{\pm0.60}$	$8.02_{\pm0.93}$	$0.052_{\pm0.007}$	$0.078_{\pm0.016}$	$3.333_{\pm0.58}^{a}$
YYU11	$7.00_{\pm0.70}^{a-d}$	$6.80_{\pm0.75}^{fg}$	$6.93_{\pm0.92}$	$9.68_{\pm2.73}$	$0.071_{\pm0.013}$	$0.099_{\pm0.008}$	$2.333_{\pm0.58}^{a-c}$
YYU12	$6.54_{\pm0.48}^{b-d}$	$7.58_{\pm0.98}^{d-f}$	$6.22_{\pm0.76}$	$8.75_{\pm2.31}$	$0.069_{\pm0.016}$	$0.119_{\pm0.033}$	$3.333_{\pm0.58}^{a}$
YYU13	$5.83_{\pm0.88}^{cd}$	$6.79_{\pm0.46}^{fg}$	$6.09_{\pm1.86}$	$8.08_{\pm1.23}$	$0.068_{\pm0.022}$	$0.083_{\pm0.031}$	$2.667_{\pm0.58}^{a-c}$
YYU14	$5.99_{\pm0.93}^{cd}$	$7.03_{\pm0.31}^{e-g}$	$6.48_{\pm2.03}$	$7.10_{\pm1.07}$	$0.090_{\pm0.026}$	$0.097_{\pm0.033}$	$2.333_{\pm0.58}^{a-c}$
YYU15	$5.90_{\pm0.20}^{cd}$	$6.66_{\pm0.71}^{fg}$	$3.69_{\pm1.77}$	$7.97_{\pm0.96}$	$0.070_{\pm0.053}$	$0.084_{\pm0.010}$	$2.000_{\pm0.00}^{bc}$
YYU18	$7.19_{\pm0.93}^{a-d}$	$8.63_{\pm0.19}^{b-e}$	$7.06_{\pm2.92}$	$8.26_{\pm2.00}$	$0.061_{\pm0.003}$	$0.087_{\pm0.012}$	$1.667_{\pm0.58}^{c}$
YYU20	$7.37_{\pm1.12}^{a-d}$	$7.06_{\pm1.38}^{e-g}$	$5.89_{\pm2.79}$	$9.55_{\pm0.45}$	$0.058_{\pm0.013}$	$0.066_{\pm0.004}$	$2.667_{\pm0.58}^{a-c}$
YYU21	$7.58_{\pm1.06}^{a-d}$	$9.74_{\pm0.40}^{a-c}$	$8.62_{\pm2.06}$	$11.81_{\pm3.57}$	$0.073_{\pm0.021}$	$0.096_{\pm0.039}$	$2.667_{\pm0.58}^{a-c}$
YYU22	$7.01_{\pm0.83}^{a-d}$	$8.64_{\pm0.88}^{b-e}$	$6.60_{\pm2.99}$	$8.98_{\pm2.15}$	$0.060_{\pm0.014}$	$0.094_{\pm0.029}$	$3.000_{\pm0.00}^{ab}$
YYU23	$7.98_{\pm0.72}^{a-c}$	$8.96_{\pm1.02}^{b-d}$	$5.74_{\pm0.75}$	$8.90_{\pm2.11}$	$0.052_{\pm0.003}$	$0.067_{\pm0.021}$	$2.667_{\pm0.58}^{a-c}$
YYU25	$6.73_{\pm0.33}^{b-d}$	$8.31_{\pm0.85}^{c-f}$	$5.61_{\pm0.68}$	$7.26_{\pm0.74}$	$0.050_{\pm0.037}$	$0.050_{\pm0.010}$	$3.000_{\pm1.00}^{ab}$
YYU29	$6.13_{\pm3.19}^{b-d}$	$8.25_{\pm0.57}^{c-f}$	$7.80_{\pm3.08}$	$9.67_{\pm2.83}$	$0.122_{\pm0.090}$	$0.069_{\pm0.014}$	$2.000_{\pm0.00}^{bc}$
YYU30	$8.89_{\pm0.87}^{ab}$	$11.29_{\pm1.64}^{a}$	$12.72_{\pm7.56}$	$9.44_{\pm1.94}$	$0.142_{\pm0.066}$	$0.092_{\pm0.040}$	$3.000_{\pm1.00}^{ab}$
Galia	$6.81_{\pm1.88}^{b-d}$	$9.02_{\pm2.11}^{b-d}$	$7.72_{\pm4.60}$	$8.07_{\pm1.19}$	$0.071_{\pm0.031}$	$0.082_{\pm0.072}$	$2.333_{\pm0.58}^{a-c}$
Kirkagac	$9.58_{\pm2.42}^{a}$	$10.12_{\pm0.25}^{a-b}$	$7.23_{\pm3.33}$	$9.02_{\pm1.67}$	$0.067_{\pm0.022}$	$0.085_{\pm0.011}$	$3.000_{\pm0.00}^{ab}$
Lokum	$7.83_{\pm2.61}^{a-c}$	$7.50_{\pm1.08}^{df}$	$5.27_{\pm3.86}$	$7.46_{\pm2.05}$	$0.049_{\pm0.006}$	$0.068_{\pm0.005}$	$1.667_{\pm0.58}^{c}$
Napolyon	$6.88_{\pm2.15}^{b-d}$	$7.91_{\pm0.92}^{df}$	$6.28_{\pm2.97}$	$7.75_{\pm0.35}$	$0.057_{\pm0.012}$	$0.069_{\pm0.006}$	$2.667_{\pm0.58}^{a-c}$
*p-value	0.061	0.000	0.398	0.581	0.227	0.253	0.052

[a] I_{100}: Full Irrigation, I_{50}: 50% Deficit Irrigation. * Significant distinctions among groups were observed at the $P< 0.05$ level, as determined by Duncan's multiple comparison test.

In deficit irrigation, genotype YYU21 had the widest (17.20 μm), and genotype YYU6 had the narrowest (10.78 μm). Regarding stoma area, genotype YYU22 had the widest (252.94 $μm^2$) in full irrigation, and genotype YYU6 had the narrowest (53.03 $μm^2$). In deficit irrigation, genotype YYU21 had the widest (288.05 $μm^2$), and genotype YYU6 had the narrowest (124.28 $μm^2$). In full irrigation, cv. Kirkagac displayed the highest stoma intensity (362.50 units per mm^2), and genotype YYU15 had the lowest (56.25 units per mm^2). Under deficit irrigation, genotype YYU6 showed the highest stoma intensity (516.67 units per mm^2), with genotype YYU15 displaying the lowest (108.33 units per mm^2).

Mineral Content

Differences in mean K, Ca, and Mg contents among melon genotypes and cultivars were significant under both full and deficit irrigation conditions, with P content showing significance exclusively in deficit irrigation (Table 6). Deficit irrigation led to a decrease in P and Mg uptake in 66% of genotypes and cultivars, while 90% experienced reduced Ca intake. In full irrigation, the highest K content occurred in genotypes YYU6 (6.28%) and YYU21 (6.25%), while the lowest was in genotype YYU20 (2.91%). Under deficit irrigation, the highest K content was in genotype YYU29 (6.58%), and the lowest was in genotype YYU12 (4.56%) and cv. Lokum (4.44%). For P content in deficit irrigation, the highest was in genotype YYU29 (0.92%), and the lowest was in genotype YYU10 (0.46%). In both full and deficit irrigation, the highest Ca content was in genotypes YYU30 (7.72 and 5.65%, respectively), and the lowest was in genotype YYU12 (3.83% and 4.22%, respectively). In full irrigation, the highest Mg content was in genotype YYU30

Table 5. Stomatal traits of melon genotypes under full (I_{100}) and deficit (I_{50}) irrigation levels: Mean values and standard deviations.[a]

Genotype	Stoma height (μm)		Stoma width (μm)		Stoma area ($μm^2$)		Stoma intensity (unit per mm^2)	
	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}
YYU1	$19.04_{\pm1.98}^{b-f}$	$17.93_{\pm1.66}^{a-f}$	$12.76_{\pm1.37}^{c-h}$	$13.82_{\pm1.37}^{a-f}$	$189.56_{\pm12.55}^{b-g}$	$194.09_{\pm20.41}^{b-g}$	$108.33_{\pm19.09}^{h-i}$	$137.50_{\pm21.65}^{gh}$
YYU4	$12.61_{\pm1.63}^{h}$	$15.90_{\pm0.80}^{d-f}$	$9.49_{\pm0.78}^{ii}$	$13.16_{\pm2.13}^{b-f}$	$94.42_{\pm18.34}^{hi}$	$164.91_{\pm33.80}^{d-f}$	$250.00_{\pm12.50}^{b-d}$	$350.00_{\pm33.07}^{b}$
YYU6	$8.47_{\pm0.71}^{i}$	$14.47_{\pm0.2}^{f}$	$7.97_{\pm0.15}^{i}$	$10.95_{\pm0.98}^{ef}$	$53.03_{\pm4.76}^{i}$	$124.28_{\pm9.46}^{f}$	$162.50_{\pm12.50}^{e-h}$	$516.67_{\pm7.22}^{a}$
YYU10	$17.32_{\pm0.64}^{c-g}$	$16.97_{\pm2.32}^{b-f}$	$13.43_{\pm0.80}^{a-g}$	$13.50_{\pm2.10}^{b-f}$	$182.38_{\pm4.70}^{c-g}$	$179.11_{\pm33.72}^{b-f}$	$129.17_{\pm28.87}^{g-i}$	$320.83_{\pm14.43}^{bc}$
YYU11	$19.02_{\pm0.98}^{b-f}$	$17.10_{\pm4.10}^{b-f}$	$14.33_{\pm1.61}^{a-d}$	$14.25_{\pm3.97}^{a-f}$	$214.76_{\pm34.44}^{a-e}$	$198.75_{\pm102.02}^{b-f}$	$216.67_{\pm14.43}^{c-e}$	$316.67_{\pm19.09}^{bc}$
YYU12	$18.82_{\pm1.50}^{b-f}$	$19.33_{\pm0.91}^{a-e}$	$14.00_{\pm1.8}^{a-e}$	$16.69_{\pm2.24}^{ab}$	$206.30_{\pm28.21}^{a-f}$	$253.59_{\pm38.79}^{a-c}$	$278.13_{\pm57.17}^{bc}$	$270.83_{\pm52.04}^{cd}$
YYU13	$16.65_{\pm1.54}^{e-g}$	$20.37_{\pm1.01}^{a-c}$	$15.58_{\pm0.70}^{a}$	$13.94_{\pm0.85}^{a-f}$	$204.03_{\pm25.93}^{a-f}$	$222.66_{\pm11.86}^{a-e}$	$312.50_{\pm54.49}^{ab}$	$133.33_{\pm7.22}^{gh}$
YYU14	$17.08_{\pm2.48}^{c-g}$	$15.40_{\pm2.46}^{def}$	$11.64_{\pm0.73}^{e-i}$	$10.78_{\pm0.85}^{f}$	$156.35_{\pm26.69}^{fg}$	$130.05_{\pm19.67}^{f}$	$220.83_{\pm127.68}^{ce}$	$212.50_{\pm12.50}^{ef}$
YYU15	$18.00_{\pm1.60}^{b-g}$	$18.60_{\pm0.56}^{a-f}$	$12.12_{\pm0.04}^{d-h}$	$13.02_{\pm1.97}^{b-f}$	$171.23_{\pm14.60}^{e-g}$	$189.50_{\pm22.77}^{b-f}$	$56.25_{\pm8.84}^{i}$	$108.33_{\pm14.43}^{h}$
YYU18	$18.09_{\pm2.75}^{b-g}$	$16.07_{\pm0.40}^{d-f}$	$10.96_{\pm1.35}^{g-i}$	$11.54_{\pm0.88}^{d-f}$	$155.50_{\pm29.53}^{fg}$	$145.77_{\pm14.85}^{ef}$	$116.67_{\pm7.22}^{h-i}$	$237.50_{\pm45.07}^{de}$
YYU20	$20.52_{\pm1.12}^{bc}$	$17.17_{\pm2.16}^{b-f}$	$14.56_{\pm1.79}^{a-d}$	$14.69_{\pm1.23}^{a-d}$	$235.00_{\pm37.37}^{a-d}$	$198.37_{\pm33.77}^{b-f}$	$87.50_{\pm12.50}^{ii}$	$200.00_{\pm45.07}^{ef}$
YYU21	$16.80_{\pm1.27}^{d-g}$	$20.97_{\pm2.65}^{ab}$	$12.98_{\pm1.40}^{b-h}$	$17.20_{\pm4.23}^{a}$	$170.25_{\pm6.95}^{e-g}$	$288.05_{\pm102.96}^{a}$	$179.17_{\pm7.22}^{e-h}$	$133.33_{\pm7.22}^{gh}$
YYU22	$23.73_{\pm2.34}^{a}$	$21.47_{\pm2.17}^{a}$	$13.56_{\pm0.61}^{a-f}$	$14.66_{\pm1.00}^{a-e}$	$252.94_{\pm31.48}^{a}$	$248.11_{\pm42.36}^{a-d}$	$75.00_{\pm21.65}^{i-i}$	$166.67_{\pm7.22}^{fg}$
YYU23	$15.27_{\pm2.20}^{gh}$	$19.97_{\pm3.09}^{a-d}$	$11.51_{\pm0.88}^{e-i}$	$12.77_{\pm1.98}^{c-f}$	$137.74_{\pm20.67}^{fg}$	$203.29_{\pm64.20}^{b-f}$	$129.17_{\pm7.22}^{g-i}$	$204.17_{\pm28.87}^{ef}$
YYU25	$16.50_{\pm1.84}^{fg}$	$21.80_{\pm2.84}^{a}$	$10.74_{\pm1.02}^{hi}$	$15.47_{\pm1.27}^{a-c}$	$138.16_{\pm6.71}^{fg}$	$264.78_{\pm42.66}^{ab}$	$137.50_{\pm21.65}^{g-i}$	$170.83_{\pm14.43}^{fg}$
YYU29	$20.06_{\pm1.79}^{b-e}$	$15.90_{\pm1.22}^{d-f}$	$15.40_{\pm1.18}^{ab}$	$15.22_{\pm0.97}^{a-d}$	$243.55_{\pm39.48}^{ab}$	$189.34_{\pm4.10}^{b-f}$	$141.67_{\pm19.09}^{f-i}$	$170.83_{\pm7.22}^{fg}$
YYU30	$19.71_{\pm2.72}^{b-f}$	$20.50_{\pm2.52}^{a-c}$	$15.21_{\pm2.34}^{a-c}$	$12.95_{\pm1.19}^{c-f}$	$238.61_{\pm70.97}^{a-c}$	$208.50_{\pm31.91}^{a-f}$	$195.83_{\pm7.22}^{d-g}$	$166.67_{\pm47.32}^{fg}$
Galia	$21.29_{\pm1.35}^{ab}$	$19.50_{\pm2.65}^{a-e}$	$13.02_{\pm1.76}^{b-h}$	$13.39_{\pm1.22}^{b-f}$	$218.30_{\pm39.26}^{a-e}$	$206.52_{\pm46.52}^{a-f}$	$87.50_{\pm33.07}^{ii}$	$133.33_{\pm14.43}^{gh}$
Kirkagac	$18.56_{\pm1.94}^{b-g}$	$16.63_{\pm0.75}^{c-f}$	$12.42_{\pm0.82}^{d-h}$	$13.72_{\pm1.65}^{a-f}$	$180.46_{\pm13.41}^{d-g}$	$179.66_{\pm29.11}^{b-f}$	$362.50_{\pm12.50}^{a}$	$279.17_{\pm40.18}^{cd}$
Lokum	$20.27_{\pm1.11}^{b-d}$	$19.60_{\pm3.55}^{a-e}$	$14.47_{\pm1.42}^{a-d}$	$11.59_{\pm1.65}^{d-f}$	$230.48_{\pm28.60}^{a-d}$	$175.43_{\pm9.58}^{c-f}$	$208.33_{\pm7.22}^{c-e}$	$200.00_{\pm54.49}^{ef}$
Napolyon	$16.41_{\pm1.91}^{fg}$	$19.67_{\pm0.35}^{a-d}$	$11.31_{\pm0.95}^{f-i}$	$12.67_{\pm0.29}^{c-f}$	$146.46_{\pm27.17}^{gh}$	$195.61_{\pm1.91}^{b-f}$	$216.67_{\pm19.09}^{c-e}$	$137.50_{\pm12.50}^{gh}$
*p-value	0.001	0.001	0.001	0.007	0.001	0.003	0.001	0.001

[a] I_{100}: Full Irrigation, I_{50}: 50% Deficit Irrigation. *: Significant distinctions among groups were observed at the P< 0.05 level, as determined by Duncan's multiple comparison test.

(7.72%), and the lowest was in genotype YYU20 (0.49%). Under deficit irrigation, the highest Mg content was in genotype YYU30 (0.73%), and the lowest was in cv. Lokum (0.48%).

Significant differences in Zn and Cu contents among melon genotypes and cultivars were observed under both full and deficit irrigation conditions. Meanwhile, Fe content showed significant differences only under full irrigation, and Mn content exhibited significance solely under limited irrigation conditions (Table 7). Approximately 76% of all genotypes and cultivars were adversely affected by deficit irrigation for Fe uptake, and all genotypes showed negative effects on Mn uptake under deficit irrigation. In full irrigation, the highest Zn content was in genotype YYU29 (238.35 ppm), and the lowest was in genotype YYU4 (47.27 ppm). Under deficit irrigation, the highest Zn content was in genotype YYU29 (193.78 ppm), and the lowest was in genotype cv. Napolyon (46.22 ppm). Regarding Cu content, in full irrigation, the highest was in genotype YYU23 (25.82 ppm), and the lowest was in genotypes YYU25 (10.39 ppm) and YYU11 (10.71 ppm). Under deficit irrigation, the highest Cu content was in genotype YYU25 (14.56 ppm), and the lowest was in genotype YYU10 (6.39 ppm). For Fe content, in full irrigation, the highest was in genotype YYU6 (232.57 ppm), and the lowest was in genotype YYU25 (111.70 ppm). In deficit irrigation, the highest Mn content was in cv. Galia (64.41 ppm), and the lowest was in cv. Kirkagac (32.67 ppm).

Enzyme Activation and MDA Content

CAT activity significantly increased under deficit irrigation, indicating a response to water stress. APX activity increased across all melon genotypes and cultivars in deficit irrigation, with significant differences found only in the full

Table 6. Macro mineral contents in melon genotypes under full and 50% deficit irrigation. [a]

Genotype	K (%)		P (%)		Ca (%)		Mg (%)	
	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}
YYU1	$6.00_{\pm 0.57}^{ac}$	$5.78_{\pm0.51}^{ac}$	$1.06_{\pm0.02}$	$0.76_{\pm0.07}^{ab}$	$5.73_{\pm0.52}^{b-e}$	$4.34_{\pm0.60}^{cd}$	$0.64_{\pm0.05}^{d-g}$	$0.57_{\pm0.06}^{b-e}$
YYU4	$4.87_{\pm0.14}^{af}$	$5.55_{\pm0.61}^{ad}$	$0.71_{\pm0.28}$	$0.85_{\pm0.10}^{ab}$	$4.39_{\pm1.48}^{ef}$	$4.28_{\pm0.52}^{cd}$	$0.71_{\pm0.09}^{c-g}$	$0.52_{\pm0.10}^{de}$
YYU6	$6.28_{\pm0.61}^{a}$	$6.09_{\pm0.91}^{ab}$	$0.86_{\pm0.33}$	$0.79_{\pm0.15}^{ab}$	$5.93_{\pm1.06}^{b-e}$	$4.31_{\pm0.75}^{cd}$	$0.69_{\pm0.20}^{d-g}$	$0.51_{\pm0.06}^{de}$
YYU10	$5.81_{\pm0.42}^{a-d}$	$5.92_{\pm0.58}^{ac}$	$0.80_{\pm0.09}$	$0.46_{\pm0.07}^{c}$	$5.75_{\pm0.65}^{b-e}$	$4.32_{\pm0.43}^{cd}$	$0.68_{\pm0.10}^{d-g}$	$0.52_{\pm0.03}^{de}$
YYU11	$4.36_{\pm0.43}^{cg}$	$4.97_{\pm0.25}^{bd}$	$0.73_{\pm0.19}$	$0.62_{\pm0.12}^{bc}$	$5.26_{\pm0.33}^{c-f}$	$4.29_{\pm0.39}^{cd}$	$0.75_{\pm0.10}^{c-f}$	$0.56_{\pm0.02}^{be}$
YYU12	$4.52_{\pm0.59}^{bf}$	$4.56_{\pm0.64}^{d}$	$0.87_{\pm0.12}$	$0.59_{\pm0.10}^{bc}$	$6.19_{\pm0.64}^{a-e}$	$4.22_{\pm0.21}^{d}$	$0.92_{\pm0.15}^{bc}$	$0.60_{\pm0.04}^{a-e}$
YYU13	$5.48_{\pm0.27}^{ae}$	$5.52_{\pm0.64}^{ad}$	$0.92_{\pm0.01}$	$0.82_{\pm0.17}^{ab}$	$7.22_{\pm0.42}^{ab}$	$5.04_{\pm0.45}^{a-d}$	$1.01_{\pm0.13}^{b}$	$0.66_{\pm0.03}^{a-c}$
YYU14	$4.76_{\pm0.22}^{af}$	$5.12_{\pm0.72}^{bd}$	$0.78_{\pm0.14}$	$0.69_{\pm0.20}^{ac}$	$5.83_{\pm0.73}^{b-e}$	$5.30_{\pm0.31}^{a-d}$	$0.71_{\pm0.17}^{c-g}$	$0.69_{\pm0.06}^{ab}$
YYU15	$3.42_{\pm0.68}^{fg}$	$5.58_{\pm0.09}^{ad}$	$0.87_{\pm0.14}$	$0.74_{\pm0.03}^{ab}$	$5.57_{\pm2.99}^{b-f}$	$4.59_{\pm0.38}^{a-d}$	$0.65_{\pm0.31}^{d-g}$	$0.57_{\pm0.02}^{b-e}$
YYU18	$3.95_{\pm0.44}^{eg}$	$5.48_{\pm0.79}^{ad}$	$0.69_{\pm0.00}$	$0.63_{\pm0.16}^{bc}$	$4.61_{\pm0.18}^{ef}$	$5.11_{\pm0.79}^{a-d}$	$0.58_{\pm0.09}^{e-g}$	$0.66_{\pm0.10}^{a-c}$
YYU20	$2.91_{\pm0.53}^{g}$	$5.19_{\pm1.17}^{bd}$	$0.78_{\pm0.03}$	$0.73_{\pm0.14}^{ab}$	$3.83_{\pm0.53}^{f}$	$4.43_{\pm0.47}^{cd}$	$0.49_{\pm0.09}^{g}$	$0.57_{\pm0.06}^{b-e}$
YYU21	$6.25_{\pm1.69}^{a}$	$5.34_{\pm0.71}^{bd}$	$0.79_{\pm0.10}$	$0.75_{\pm0.11}^{ab}$	$6.45_{\pm0.51}^{a-d}$	$4.87_{\pm0.30}^{a-d}$	$0.85_{\pm0.18}^{b-d}$	$0.69_{\pm0.05}^{a-b}$
YYU22	$5.29_{\pm1.19}^{ae}$	$5.33_{\pm0.46}^{bd}$	$0.98_{\pm0.11}$	$0.76_{\pm0.06}^{ab}$	$5.55_{\pm0.98}^{b-f}$	$5.10_{\pm0.60}^{a-d}$	$0.65_{\pm0.10}^{d-g}$	$0.64_{\pm0.14}^{a-d}$
YYU23	$5.32_{\pm0.29}^{ae}$	$5.33_{\pm0.16}^{bd}$	$0.93_{\pm0.00}$	$0.69_{\pm0.35}^{ac}$	$6.83_{\pm0.17}^{a-c}$	$4.53_{\pm1.17}^{b-d}$	$0.78_{\pm0.06}^{c-e}$	$0.58_{\pm0.04}^{b-e}$
YYU25	$4.52_{\pm0.04}^{bf}$	$4.71_{\pm0.80}^{cd}$	$0.71_{\pm0.36}$	$0.85_{\pm0.07}^{ab}$	$6.06_{\pm0.54}^{a-e}$	$4.97_{\pm0.62}^{a-d}$	$0.70_{\pm0.08}^{c-g}$	$0.61_{\pm0.09}^{a-d}$
YYU29	$4.64_{\pm1.47}^{af}$	$6.58_{\pm0.69}^{a}$	$0.85_{\pm0.21}$	$0.92_{\pm0.12}^{a}$	$5.14_{\pm1.32}^{c-f}$	$5.53_{\pm0.36}^{ab}$	$0.60_{\pm0.11}^{e-g}$	$0.67_{\pm0.02}^{ab}$
YYU30	$6.16_{\pm1.45}^{ab}$	$5.01_{\pm0.19}^{bd}$	$0.85_{\pm0.17}$	$0.65_{\pm0.04}^{bc}$	$7.72_{\pm1.25}^{a}$	$5.65_{\pm0.34}^{a}$	$1.41_{\pm0.01}^{a}$	$0.73_{\pm0.05}^{a}$
Galia	$5.14_{\pm0.37}^{ae}$	$4.87_{\pm0.18}^{cd}$	$0.93_{\pm0.12}$	$0.74_{\pm0.08}^{ab}$	$6.12_{\pm0.61}^{a-e}$	$5.37_{\pm0.56}^{a-c}$	$0.67_{\pm0.09}^{d-g}$	$0.64_{\pm0.07}^{a-d}$
Kirkagac	$4.32_{\pm1.55}^{dg}$	$5.23_{\pm0.58}^{bd}$	$0.78_{\pm0.26}$	$0.69_{\pm0.07}^{ac}$	$5.13_{\pm0.74}^{c-f}$	$4.69_{\pm0.37}^{a-d}$	$0.55_{\pm0.02}^{e-g}$	$0.53_{\pm0.04}^{c-e}$
Lokum	$5.09_{\pm1.03}^{ae}$	$4.44_{\pm0.53}^{d}$	$0.85_{\pm0.33}$	$0.80_{\pm0.10}^{ab}$	$5.00_{\pm0.36}^{d-f}$	$4.78_{\pm0.25}^{a-d}$	$0.52_{\pm0.08}^{f-g}$	$0.48_{\pm0.03}^{e}$
Napolyon	$5.73_{\pm0.03}^{ad}$	$4.97_{\pm0.27}^{b-d}$	$0.83_{\pm0.01}$	$0.77_{\pm0.01}^{ab}$	$5.34_{\pm1.25}^{c-f}$	$5.08_{\pm0.74}^{a-d}$	$0.61_{\pm0.10}^{d-g}$	$0.60_{\pm0.11}^{a-e}$
*p-value	0.000	0.020	0.709	0.051	0.001	0.031	0.000	0.001

[a] I_{100}: Full irrigation, I_{50}: 50% deficit irrigation, *: Significant distinctions among groups were observed at the $P < 0.05$ level, as determined by Duncan's multiple comparison test.

Table 7. Micro mineral contents in melon genotypes under full (I_{100}) and deficit (I_{50}) irrigation levels.[a]

Genotype	Zn (ppm)		Cu (ppm)		Fe (ppm)		Mn (ppm)	
	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}
YYU1	$130.26_{\pm106.20}^{b-g}$	$67.01_{\pm43.97}^{e-g}$	$13.63_{\pm1.06}^{c-f}$	$6.81_{\pm0.89}^{ef}$	$162.10_{\pm37.56}^{b-f}$	$134.56_{\pm20.15}$	$67.29_{\pm12.60}$	$43.21_{be\pm8.46}$
YYU4	$47.27_{\pm10.28}^{g}$	$164.38_{\pm12.30}^{a-c}$	$18.63_{\pm2.39}^{b}$	$6.61_{\pm0.04}^{ef}$	$155.20_{\pm10.19}^{c-f}$	$136.38_{\pm7.82}$	$60.74_{\pm20.91}$	$37.87_{ce\pm9.79}$
YYU6	$147.04_{\pm104.75}^{a-f}$	$157.13_{\pm23.60}^{a-d}$	$11.88_{\pm1.87}^{df-}$	$8.35_{\pm1.77}^{c-f}$	$232.57_{\pm69.14}^{a}$	$162.69_{\pm5.29}$	$68.66_{\pm22.35}$	$50.87_{ad\pm6.39}$
YYU10	$183.23_{\pm35.97}^{a-e}$	$50.91_{\pm11.64}^{f-g}$	$11.18_{\pm0.65}^{ef}$	$6.39_{\pm0.42}^{f}$	$149.46_{\pm8.51}^{c-f}$	$123.35_{\pm4.33}$	$63.18_{\pm20.97}$	$39.95_{be\pm2.19}$
YYU11	$140.05_{\pm52.77}^{a-g}$	$178.57_{\pm7.78}^{ab}$	$10.71_{\pm1.13}^{f}$	$7.09_{\pm1.19}^{e-f}$	$160.95_{\pm9.29}^{b-f}$	$153.55_{\pm21.76}$	$75.77_{\pm4.99}$	$40.67_{be\pm6.39}$
YYU12	$121.00_{\pm21.96}^{c-g}$	$129.88_{\pm6.49}^{a-f}$	$12.50_{\pm1.64}^{c-f}$	$8.10_{\pm0.65}^{c-f}$	$165.81_{\pm14.91}^{b-f}$	$139.63_{\pm8.69}$	$73.66_{\pm23.93}$	$52.88_{ac\pm4.89}$
YYU13	$89.32_{\pm52.03}^{e-g}$	$62.54_{\pm18.39}^{fg}$	$14.72_{\pm2.76}^{b-f}$	$6.50_{\pm2.14}^{f}$	$185.54_{\pm4.53}^{a-e}$	$141.08_{\pm7.42}$	$92.86_{\pm15.06}$	$55.40_{ab\pm8.37}$
YYU14	$172.39_{\pm54.82}^{a-e}$	$69.13_{\pm48.34}^{e-g}$	$12.00_{\pm1.45}^{d-f}$	$7.48_{\pm0.93}^{d-f}$	$191.18_{\pm18.82}^{a-d}$	$145.41_{\pm17.35}$	$89.48_{\pm26.99}$	$47.9_{be\pm8.61}$
YYU15	$219.47_{\pm31.76}^{a-c}$	$114.18_{\pm64.39}^{b-g}$	$11.60_{\pm0.18}^{ef}$	$11.10_{\pm3.17}^{bc}$	$169.04_{\pm1.20}^{b-f}$	$177.98_{\pm40.13}$	$49.98_{\pm23.99}$	$34.20_{de\pm1.05}$
YYU18	$150.62_{\pm25.86}^{a-f}$	$57.85_{\pm62.04}^{f-g}$	$13.00_{\pm1.26}^{c-f}$	$9.33_{\pm0.35}^{c-f}$	$215.94_{\pm60.01}^{ab}$	$130.42_{\pm8.76}$	$74.21_{\pm5.87}$	$40.13_{be\pm4.75}$
YYU20	$173.19_{\pm73.28}^{a-e}$	$119.20_{\pm18.38}^{a-g}$	$14.24_{\pm0.90}^{b-f}$	$9.11_{\pm1.63}^{c-f}$	$147.46_{\pm7.77}^{c-f}$	$168.24_{\pm88.29}$	$65.51_{\pm18.79}$	$39.96_{be\pm9.89}$
YYU21	$156.17_{\pm75.16}^{a-f}$	$61.42_{\pm27.11}^{fg}$	$12.70_{\pm1.44}^{c-f}$	$9.40_{\pm0.14}^{c-f}$	$155.61_{\pm21.06}^{c-f}$	$146.78_{\pm26.75}$	$68.18_{\pm21.50}$	$46.23_{be\pm5.28}$
YYU22	$226.33_{\pm43.38}^{ab}$	$99.74_{\pm57.25}^{b-g}$	$12.92_{\pm0.41}^{c-f}$	$9.78_{\pm0.26}^{c-f}$	$149.75_{\pm6.44}^{c-f}$	$128.18_{\pm7.89}$	$59.81_{\pm5.89}$	$34.77_{de\pm3.16}$
YYU23	$57.31_{\pm1.51}^{fg}$	$99.26_{\pm18.13}^{b-g}$	$25.82_{\pm7.49}^{a}$	$7.68_{\pm1.95}^{c-f}$	$128.97_{\pm5.14}^{ef}$	$101.85_{\pm39.90}$	$81.25_{\pm17.10}$	$44.03_{be\pm18.17}$
YYU25	$96.00_{\pm24.49}^{d-g}$	$86.00_{\pm83.82}^{c-g}$	$10.39_{\pm2.05}^{f}$	$14.56_{\pm4.35}^{a}$	$111.70_{\pm39.83}^{f}$	$134.48_{\pm17.05}$	$57.89_{\pm33.99}$	$44.84_{be\pm8.36}$
YYU29	$238.35_{\pm23.15}^{a}$	$193.78_{\pm1.36}^{a}$	$12.84_{\pm3.13}^{c-f}$	$10.72_{\pm2.58}^{b-d}$	$142.19_{\pm8.77}^{d-f}$	$117.36_{\pm4.07}$	$88.90_{\pm11.45}$	$41.48_{be\pm9.41}$
YYU30	$217.16_{\pm15.01}^{a-c}$	$78.90_{\pm55.14}^{d-g}$	$16.02_{\pm0.58}^{b-e}$	$9.25_{\pm0.98}^{c-f}$	$206.30_{\pm55.75}^{a-c}$	$139.05_{\pm48.08}$	$95.26_{\pm30.12}$	$42.74_{be\pm6.74}$
Galia	$95.83_{\pm23.83}^{d-g}$	$144.02_{\pm29.03}^{a-e}$	$14.25_{\pm1.13}^{b-f}$	$11.09_{\pm1.86}^{bc}$	$181.86_{\pm21.21}^{a-e}$	$219.30_{\pm70.51}$	$98.72_{\pm22.67}$	$64.41_{a\pm16.84}$
Kirkagac	$148.50_{\pm72.15}^{a-f}$	$52.6_{\pm17.37}^{f-g}$	$12.62_{\pm2.11}^{c-f}$	$8.43_{\pm0.62}^{c-f}$	$137.45_{\pm25.57}^{d-f}$	$150.76_{\pm35.76}$	$59.58_{\pm5.41}$	$32.67_{e\pm1.86}$
Lokum	$185.73_{\pm9.31}^{a-e}$	$146.74_{\pm79.52}^{a-e}$	$17.03_{\pm2.03}^{bc}$	$10.17_{\pm1.11}^{c-e}$	$169.38_{\pm35.88}^{b-f}$	$136.44_{\pm14.47}$	$54.66_{\pm26.67}$	$39.72_{be\pm11.90}$
Napolyon	$194.65_{\pm3.52}^{a-d}$	$46.22_{\pm7.29}^{g}$	$16.69_{\pm4.49}^{b-d}$	$13.96_{\pm3.15}^{ab}$	$159.86_{\pm13.59}^{b-f}$	$143.42_{\pm16.24}$	$58.99_{\pm15.33}$	$35.18_{de\pm2.30}$
*p-value	0.001	0.000	0.000	0.000	0.002	0.094	0.144	0.008

[a] I_{100}: Full Irrigation, I_{50}: 50% Deficit Irrigation; * Significant distinctions among groups were observed at the $P< 0.05$ level, as determined by Duncan's multiple comparison test.

irrigation group (Table 8). SOD enzyme activity increased with deficit irrigation, and MDA content increased in 76% of genotypes, yet no significant differences were observed among genotypes and cultivars in full and restricted irrigation applications. CAT activity in melon genotypes showed a 57.14% decrease under deficit irrigation-induced water stress. The genotype YYU25 exhibited the highest CAT content (0.104 mmol g^{-1} FW), followed by cv. Kirkagac (0.086 mmol g^{-1} FW), and then genotypes YYU14, YYU23, YYU29, YYU30, and cv. Lokum (0.040-0.040 mmol g^{-1} FW). Other melon genotypes and cultivars displayed lower CAT content. In full irrigation, the highest APX content was in genotype YYU4 (0.714 mmol g^{-1} FW), while the lowest Fe content was in genotype YYU29 (0.152 mmol g^{-1} FW).

Principle Component (PCA) and Cluster Analysis

Eigenvalues and variances resulting from PCA elucidated the contributions of traits (PCA loads) causing distinctions in deficit irrigation. In the analysis encompassing 28 traits, the first six components with Eigenvalues exceeding 1.00 collectively explicated 77.91% of the total variation (Table 9). PC1 (32.36%) was primarily influenced by APX, SFW, RFW, SDW, 0-5 scale, and Mn content. PC2 (15.39%) was characterized by leaf number, shoot diameter, shoot length, RDW, R/S, and Cu content. PC3 (11.32%) featured stoma length, width, and area as prominent contributors. PC4 (8.77%) revealed the significance of RDM, K, Ca, Mg, and Fe contents. PC5 (5.73%) and PC6 (4.34%) portrayed the importance of MDA, SDM, and P content in the former, while CAT, SOD, stoma density, root length, and Zn content were crucial in the latter (Table 9).

A loading plot, derived from the initial two Components (PC1 and PC2), elucidated the intricate relationships among the 28 examined traits (Figure 1). A corresponding score plot, integrating PC1 and PC2 components, effectively depicted the impact of deficit irrigation (Figure 2). Notably, a clear demarcation was observed between full and deficit irrigation applications, with a

Table 8. Enzyme activation and MDA content in melon genotypes under full (I_{100}) and deficit (I_{50}) irrigation levels.[a]

Genotip	CAT (mmol g^{-1} FW)		SOD (U mg^{-1} FW)		APX (mmol g^{-1} FW)		MDA (µmol g^{-1} FW)	
	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}	I_{100}	I_{50}
YYU1	$0.052_{\pm 0.023}$	$0.004_{\pm 0.002}^{c}$	$82.68_{\pm 45.60}$	$274.48_{\pm 223.88}$	$0.393_{\pm 0.287}^{a-f}$	$1.101_{\pm 0.352}$	$2.624_{\pm 0.711}$	$2.624_{\pm 0.756}$
YYU4	$0.013_{\pm 0.010}$	$0.015_{\pm 0.007}^{c}$	$83.86_{\pm 27.82}$	$312.28_{\pm 69.96}$	$0.714_{\pm 0.245}^{a}$	$1.548_{\pm 0.267}$	$3.570_{\pm 1.273}$	$3.355_{\pm 1.419}$
YYU6	$0.110_{\pm 0.006}$	$0.017_{\pm 0.017}^{c}$	$104.33_{\pm 16.83}$	$267.38_{\pm 141.04}$	$0.571_{\pm 0.161}^{a-d}$	$1.313_{\pm 0.180}$	$3.140_{\pm 0.521}$	$2.968_{\pm 1.677}$
YYU10	$0.023_{\pm 0.011}$	$0.005_{\pm 0.005}^{c}$	$103.33_{\pm 13.33}$	$252.12_{\pm 85.92}$	$0.506_{\pm 0.037}^{a-e}$	$1.077_{\pm 0.172}$	$4.000_{\pm 0.785}$	$6.194_{\pm 1.707}$
YYU11	$0.069_{\pm 0.006}$	$0.030_{\pm 0.025}^{c}$	$98.72_{\pm 17.95}$	$167.02_{\pm 40.83}$	$0.473_{\pm 0.045}^{a-f}$	$1.393_{\pm 0.179}$	$4.430_{\pm 0.521}$	$5.548_{\pm 1.359}$
YYU12	$0.076_{\pm 0.069}$	$0.024_{\pm 0.033}^{c}$	$103.28_{\pm 32.44}$	$266.15_{\pm 23.56}$	$0.670_{\pm 0.143}^{ab}$	$1.411_{\pm 0.240}$	$5.129_{\pm 0.581}$	$6.409_{\pm 1.171}$
YYU13	$0.076_{\pm 0.019}$	$0.015_{\pm 0.025}^{c}$	$89.35_{\pm 8.10}$	$393.65_{\pm 240.29}$	$0.586_{\pm 0.163}^{a-c}$	$1.113_{\pm 0.552}$	$4.710_{\pm 0.281}$	$4.903_{\pm 1.617}$
YYU14	$0.027_{\pm 0.015}$	$0.048_{\pm 0.017}^{bc}$	$93.61_{\pm 11.23}$	$156.78_{\pm 111.66}$	$0.571_{\pm 0.093}^{a-d}$	$1.060_{\pm 0.435}$	$3.828_{\pm 1.659}$	$3.484_{\pm 0.930}$
YYU15	$0.035_{\pm 0.039}$	$0.036_{\pm 0.009}^{c}$	$98.53_{\pm 4.35}$	$336.39_{\pm 123.65}$	$0.429_{\pm 0.227}^{a-f}$	$0.887_{\pm 0.627}$	$5.355_{\pm 0.091}$	$3.484_{\pm 1.466}$
YYU18	$0.037_{\pm 0.018}$	$0.024_{\pm 0.012}^{c}$	$99.85_{\pm 66.69}$	$180.90_{\pm 80.44}$	$0.458_{\pm 0.135}^{a-f}$	$1.083_{\pm 0.318}$	$5.376_{\pm 1.624}$	$7.312_{\pm 5.099}$
YYU20	$0.095_{\pm 0.071}$	$0.013_{\pm 0.015}^{c}$	$91.81_{\pm 39.10}$	$222.62_{\pm 132.01}$	$0.345_{\pm 0.220}^{b-f}$	$1.131_{\pm 0.530}$	$4.301_{\pm 0.878}$	$5.118_{\pm 1.496}$
YYU21	$0.050_{\pm 0.022}$	$0.017_{\pm 0.027}^{c}$	$100.39_{\pm 16.92}$	$273.18_{\pm 162.02}$	$0.232_{\pm 0.107}^{ef}$	$1.113_{\pm 0.072}$	$4.086_{\pm 0.269}$	$6.323_{\pm 2.323}$
YYU22	$0.014_{\pm 0.015}$	$0.026_{\pm 0.029}^{c}$	$118.53_{\pm 49.18}$	$272.22_{\pm 39.15}$	$0.440_{\pm 0.213}^{a-f}$	$1.238_{\pm 0.438}$	$5.505_{\pm 2.168}$	$7.785_{\pm 7.254}$
YYU23	$0.052_{\pm 0.051}$	$0.040_{\pm 0.019}^{bc}$	$116.63_{\pm 85.74}$	$294.33_{\pm 121.03}$	$0.369_{\pm 0.021}^{b-f}$	$1.298_{\pm 0.254}$	$5.591_{\pm 1.871}$	$4.817_{\pm 2.831}$
YYU25	$0.053_{\pm 0.002}$	$0.104_{\pm 0.084}^{a}$	$118.31_{\pm 38.39}$	$339.11_{\pm 286.34}$	$0.268_{\pm 0.263}^{c-f}$	$0.839_{\pm 0.568}$	$3.656_{\pm 0.197}$	$4.430_{\pm 0.711}$
YYU29	$0.042_{\pm 0.059}$	$0.047_{\pm 0.005}^{bc}$	$105.19_{\pm 33.61}$	$360.50_{\pm 64.62}$	$0.152_{\pm 0.116}^{f}$	$1.262_{\pm 0.332}$	$3.613_{\pm 1.359}$	$4.860_{\pm 0.662}$
YYU30	$0.055_{\pm 0.048}$	$0.044_{\pm 0.004}^{bc}$	$129.06_{\pm 70.78}$	$398.75_{\pm 163.67}$	$0.304_{\pm 0.000}^{c-f}$	$0.702_{\pm 0.320}$	$4.344_{\pm 0.537}$	$4.473_{\pm 1.844}$
Galia	$0.033_{\pm 0.018}$	$0.015_{\pm 0.020}^{c}$	$118.38_{\pm 37.70}$	$471.32_{\pm 347.81}$	$0.423_{\pm 0.297}^{a-f}$	$0.857_{\pm 0.295}$	$3.269_{\pm 0.649}$	$3.699_{\pm 1.171}$
Kirkagac	$0.045_{\pm 0.016}$	$0.086_{\pm 0.029}^{ab}$	$82.94_{\pm 43.06}$	$135.11_{\pm 38.43}$	$0.232_{\pm 0.125}^{ef}$	$0.774_{\pm 0.260}$	$4.645_{\pm 0.683}$	$5.677_{\pm 3.307}$
Lokum	$0.093_{\pm 0.127}$	$0.050_{\pm 0.030}^{bc}$	$101.74_{\pm 22.80}$	$230.04_{\pm 200.48}$	$0.411_{\pm 0.054}^{a-f}$	$0.792_{\pm 0.115}$	$3.441_{\pm 0.778}$	$5.204_{\pm 3.492}$
Napolyon	$0.040_{\pm 0.054}$	$0.022_{\pm 0.013}^{c}$	$86.56_{\pm 13.04}$	$412.12_{\pm 243.99}$	$0.244_{\pm 0.108}^{d-f}$	$1.268_{\pm 0.189}$	$3.656_{\pm 2.086}$	$6.538_{\pm 3.662}$
*p-value	0.472	0.003	0.995	0.606	0.005	0.481	0.074	0.658

[a] I_{100}: Full Irrigation, I_{50}: 50% Deficit Irrigation; * Significant distinctions among groups were observed at the $P < 0.05$ level, as determined by Duncan's multiple comparison test.

propensity for close proximity. Additionally, in the deficit irrigation application, genotypes YYU25 and YYU29 were discernibly positioned in the positive regions of both PC1 and PC2. These findings underscore the nuanced interplay of traits under deficit irrigation conditions, shedding light on the pivotal role of certain genotypes in this context.

DISCUSSION

Water scarcity poses a significant challenge to agriculture, impacting crop productivity and yield. Deficit Irrigation (DI), a water conservation strategy, influences physiological and yield traits in crop genotypes. The response to DI varies across species and cultivars, emphasizing the importance of understanding this variability for effective water management. Studies on upland cotton (Matniyazova *et al*., 2022) and muskmelon (Pandey *et al*., 2018) underscored the significance of genetic variability in drought tolerance traits, suggesting the potential for developing drought-tolerant cultivars. Similarly, the present study on melon revealed varying responses among genotypes and cultivars to deficit irrigation.

The observed fluctuations in parameters indicate both positive and negative impacts of stress. Notably, SDM and RDM, stomatal width, stomatal density, K, APX, SOD enzymes, and MDA increased, while other parameters (shoot and root length, stem diameter, left number, shoot fresh and dry weight, root fresh and dry weight, stoma height and area, Mg, Ca, P, Zn, Cu, Fe, Mn and CAT) decreased. Overall, deficit irrigation adversely affected plant growth, aligning with the common response of decreased growth rate and visible stress symptoms (Dasgan *et al*., 2002; Cakmakci *et al*., 2022b). Genotypic variations were evident in the reduction of leaves, shoot length, shoot diameter, root length, SDW,

Table 9. PCA loads of the investigated properties in deficit irrigation.[a]

	PC1	PC2	PC3	PC4	PC5	PC6
Eigenvalues	9.06	4.309	3.17	2.46	1.61	1.21
Explained proportion of variation (%)	32.36	15.39	11.32	8.77	5.73	4.34
Cumulative proportion of variation (%)	32.36	47.75	59.07	67.84	73.57	77.91
Factors (Eigen Vectors)						
CAT	-0.105	-0.174	0.012	0.010	0.066	**0.403**
SOD	0.255	0.055	0.051	0.027	-0.089	**-0.314**
APX	**0.249**	**0.249**	-0.063	0.070	-0.067	-0.091
MDA	0.109	0.116	0.206	-0.128	**0.450**	-0.048
Stoma length	0.069	-0.075	**0.452**	-0.235	-0.124	-0.078
Stoma width	0.109	0.029	**0.460**	0.018	-0.138	0.161
Stoma area	0.097	-0.029	**0.507**	-0.107	-0.142	0.054
Stoma density	0.095	0.114	-0.202	0.186	0.085	**0.567**
Leaf number	-0.196	**-0.282**	-0.006	-0.234	0.122	-0.137
Shoot diameter	-0.216	**0.317**	0.004	0.005	-0.058	-0.018
Shoot length	-0.147	**-0.295**	-0.095	-0.234	0.156	-0.095
Root length	-0.170	0.176	0.085	0.106	0.072	**-0.212**
SFW	**-0.287**	0.176	-0.016	-0.093	-0.031	-0.106
RFW	**-0.267**	0.242	0.051	-0.071	0.057	0.034
SDW	**-0.262**	0.170	0.026	-0.158	0.170	-0.051
RDW	-0.167	**0.337**	0.179	0.039	0.171	0.062
SDM	0.200	-0.133	0.115	-0.010	**0.420**	0.141
RDM	0.214	0.022	0.203	**0.249**	0.142	0.011
R/S	-0.219	**0.321**	0.096	0.064	-0.055	-0.025
0-5 Scale	**0.299**	0.152	-0.011	0.006	0.010	-0.085
K	0.085	-0.069	-0.131	**0.445**	-0.105	-0.261
Ca	-0.163	-0.193	0.138	**0.368**	0.171	-0.152
Mg	-0.113	-0.095	0.209	**0.447**	0.237	-0.027
P	-0.153	-0.216	0.093	0.119	**-0.352**	-0.175
Cu	-0.178	**-0.277**	0.025	-0.004	0.160	-0.042
Fe	-0.172	0.037	0.018	**0.251**	-0.079	0.074
Mn	**-0.247**	-0.103	0.146	0.199	-0.006	0.104
Zn	-0.115	-0.102	0.102	0.000	-0.396	**0.335**

[a] SFW: Shoot Fresh Weight, RFW: Root Fresh Weight, SDW: Shoot Dry Weight, RDW: Root Dry Weight, SDM: Shoot Dry Matter, RDM: Root Dry Matter, R/S: Root-to-Rhoot ratio (dry weight %).

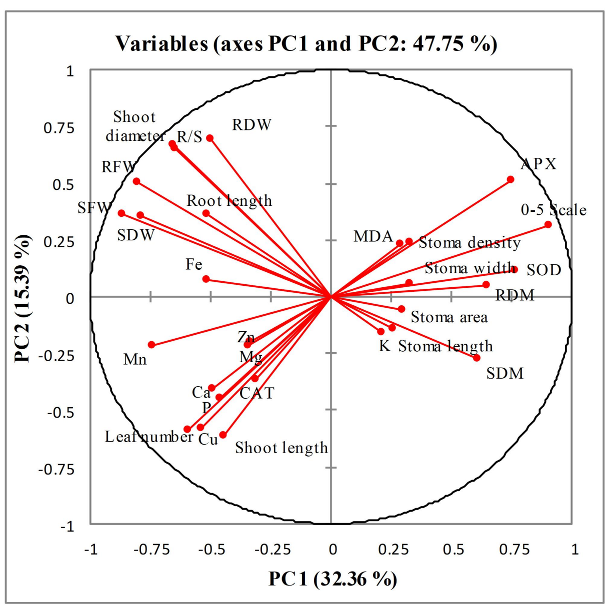

Figure 1. PCA loading plot of study traits using the first two principal components.

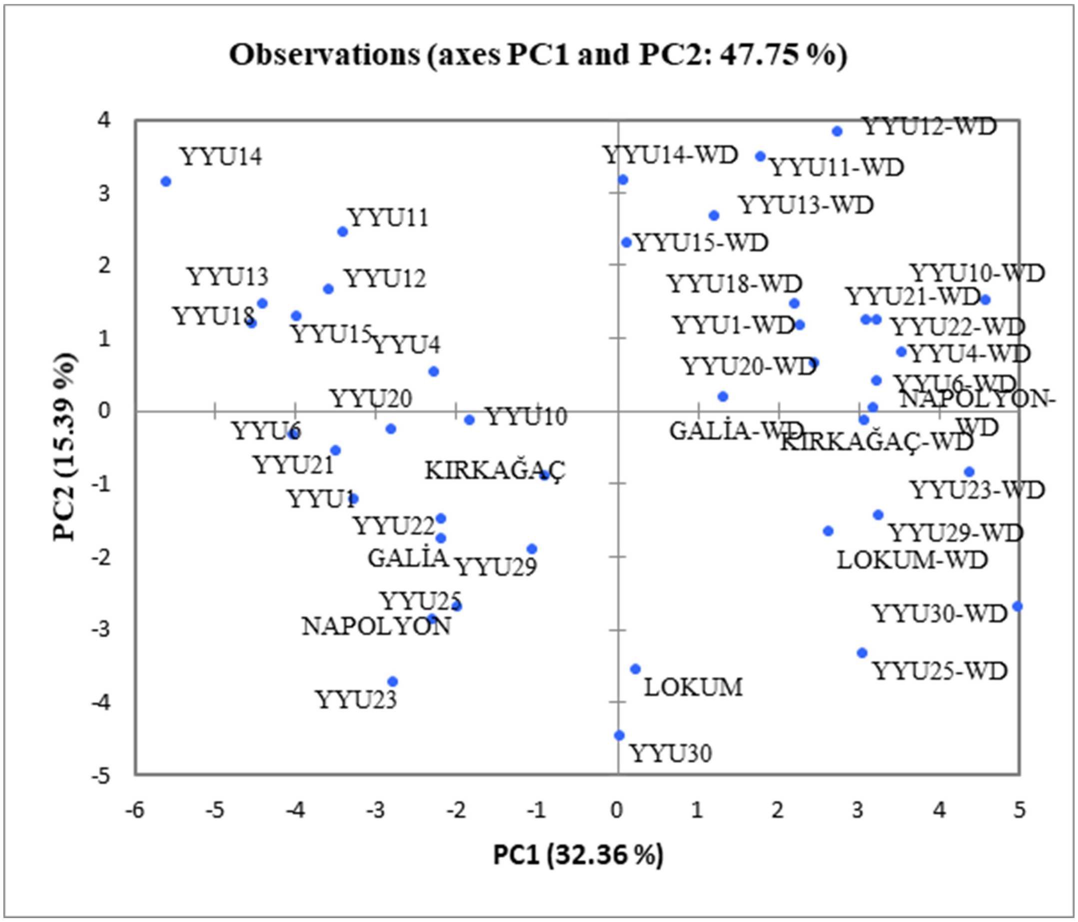

Figure 2. Melon genotypes/cultivars under full (I_{100}) and deficit (I_{50}) irrigation conditions (-WD Suffix) mapped on PCA Score Plot.

RFW, and RDW under stress. The root system, that is crucial for water uptake, suffered significant decreases, likely impacting water retention and, consequently, plant survival.

Root length, a key indicator of drought avoidance, was negatively affected, aligning with studies emphasizing the importance of a long root system in drought tolerance (Serraj *et al*., 2004). The study implies that decreased root length results from stress-induced damage to cell growth and division. The effects of DI on root growth have been reported, suggesting stimulation of root growth and improved water use efficiency (Costa *et al*., 2007).

A notable finding is the increase in SDM and RDM ratio under stress, indicating better water-holding capacity in more stress-tolerant plants. This aligns with the notion that higher water-holding capacity correlates with better drought tolerance. However, such changes in dry matter ratios may also be indicative of osmotic stress (Kravić *et al*., 2013). The negative impact of stress on the nutritional status of plants was evident, with decreases in P, Ca, Mg, Zn, Cu, Fe, and Mn uptake, except for a 67% increase in K uptake. Potassium, vital for osmoregulation and enzyme activation, demonstrated an increased role under stress, potentially maintaining osmotic balance. The observed decrease in Ca uptake aligns with reports of limited mobility in the phloem, restricting Ca transport under water limitation (Hessini *et al*., 2009; Kiegle *et al*., 2000).

Enzyme activities showed a nuanced response, with a 57.14% decrease in CAT activity and increased SOD and APX activities in genotypes under water stress. Antioxidative enzymes, crucial during stress, are stimulated to defend against stress. The elevated MDA content in 76% of genotypes suggests cell membrane damage under stress conditions. One of the most important effects of water shortage stress is the decrease in plant nutritional elements and the other is the damage to the cell walls. Malondialdehyde (MDA), as an indicator of oxidative damage caused by water shortage stress, increased in the leaf tissues of all melon genotypes in the experiment after the stress application (Kıratlı *et al*. 2015). In melon, it was determined that the amount of MDA in the leaves of drought-stressed plants was significantly higher than in the control plants (Kusvuran, 2010). SOD, CAT, GR, APX enzyme activities are stimulated under drought stress conditions (Mohammadkhani and Heidari, 2007; Bahadur *et al*., 2011; Fghire *et al*., 2013). In this study, the results of which were given, increased enzyme activities such as SOD and APX occurred due to stress factor and injury. It has been determined that these increases are at varying rates. Sources point out that increases in enzyme activation may have an effective role in establishing drought tolerance of genotypes (Kıran *et al*. 2015). MDA levels have been linked to plant stress responses, varying across species and varieties. The findings align with other studies reporting increased MDA content under drought stress (Sevengor *et al*., 2011; Sánchez-Rodríguez *et al*., 2010; Keling *et al*., 2013), highlighting the variability in stress responses.

PCA analysis effectively elucidated stress-induced variations, explaining 47.75% of the total variation. The differentiation among irrigation regimes and mycorrhizal inoculum in melon plants further emphasizes the importance of selecting appropriate parameters for discriminating among treatments. The relationship between vectors, as illustrated in Figure 1, provides insights into the positive correlation within certain growth and physiological parameters. This study concludes by emphasizing the complexity of plant responses to deficit irrigation and the need for tailored approaches to mitigate the impact of water stress on crop productivity.

CONCLUSIONS

Global challenges like population growth and environmental issues demand sustainable solutions in agriculture. Deficit irrigation (DI) stands out as an effective water-saving strategy for melon production, but its impact varies among plants. Genetic diversity plays a crucial role in developing drought-tolerant cultivars, a key focus in breeding programs. This study, conducted in the Lake Van Basin, highlights variations in melon genotypes' responses to deficit irrigation. Promising genotypes, selected for traits like seedling development and ion balance, show potential for future breeding programs, enhancing fruit quality and sustainability. In summary, addressing water scarcity requires leveraging genetic diversity and tailored breeding efforts. The identified genotypes offer promising prospects for sustainable agriculture in water-scarce regions like the Lake Van Basin.

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تغییر در برخی پارامترهای رشد نهال، محتوای مواد مغذی و فعالیت آنزیمی در ژنوتیپ‌های مختلف خربزه (*Cucumis melo* L.) در شرایط کم آبیاری

اوزلم کاکماکچی، سلما کیپچاک بیتیک، آیتکین اکینشیالپ، چکناس اردینچ، تورگای کابای، فوات ایسر، و سوات سنسوی

چکیده

نیاز روزافزون به اقدامات سازگاری با خشکسالی برای حفظ آب و عملکرد محصول در مناطق کم‌آب ناشی از خشکسالی‌های شدید و مکرر است. دستیابی به تولید پایدار مستلزم مطالعه کم آبیاری به عنوان وسیله ای برای افزایش بهره وری آب و انتخاب ژنوتیپ های مقاوم به کمبود آب خاک است. در این پژوهش، از ۱۷ ژنوتیپ مختلف خربزه (.*Cucumis melo L*) جمع آوری شده از حوضه دریاچه وان (Van Lake Basin) و ۳ هیبرید و ۱ رقم استاندارد خربزه برای کنترل این هدف استفاده شد. این بررسی در شرایط آب و هوای اتاق (climate room conditions) انجام شد. در این بررسي، ازدو سطح آبیاری مختلف (I_{100}: 100٪ آبیاری کامل، I_{50}: 50٪ کم آبیاری-DI) برای کم آبیاری استفاده شد. کاربرد آب با ظهور دومین برگ واقعی گیاه شروع شد و پس از یک ماه، رشد، مواد مغذی و محتوای آنزیمی متفاوت نهال ها تعیین شد. به طور کلی، مشخص شد که مصرف کم آب بر رشد گیاهچه تأثیر منفی داشت و ماده خشک ریشه، باز شدن و تراکم روزنه، آنزیم های پتاسیم، APX و SOD و محتوای MDA افزایش و سایر پارامترهای آزمایش شده کاهش یافت. ژنوتیپ‌های خربزه حوضه دریاچه وان در پاسخ به تیمارهای کم آبیاری متفاوت بود.