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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Effects of Deficit Irrigation to Some Bio – Active Compounds, Quality Traits and Grain Yield in Maize

Kısıtlı Sulama Uygulamalarının Mısırda Bazı Biyo – Aktif Bileşenler, Kalite Özellikleri ve Tane Verimine Etkileri

Elif ÖZDEMİR[1*], Bayram SADE[2]

Abstract

As a result of environmental difficulties and water scarcity, maize production has been challenged in arid and semi – arid regions. A management strategy for stabilizing corn production under water shortage conditions involves the use of drought – tolerant hybrids and suitable irrigation regimes. The study was conducted in the Prof. Dr. Abdulkadir AKÇIN trial area of "Selcuk University, Agriculture Faculty, Crop Science Department, Konya, TÜRKİYE" during 2019 and 2020 growing seasons. The aim of the current work is determining the effects of deficit irrigation and grain colour factors on water shortage tolerance of maize in terms of bio – active compounds, quality traits and grain yield. The factors of the trial were irrigations [50% (I1), 75% (I2) and 100% (I3) of evaporation from Class A evaporation PAN] and genotypes [DKC 5783, red corn and Sakarya]. It was noted that DKC 5783 had the highest values at two (thousand grain weight, grain yield), Sakarya had at two (total phenolic compounds and grain crude oil) and red corn had at four (total anthocyanin content, total antioxidant activity, grain crude protein and starch) properties among eight under I1 during 2019 as well as red corn had at two (total anthocyanin content and total phenolic compounds), Sakarya had at two (grain crude protein and grain crude oil) and DKC 5783 had highest values at four (thousand grain weight, total antioxidant activity, starch and grain yield) features among eight under I1 during 2020. Thousand grain weight values of I3 were 6.71% and 0.57% more than I2 while starch was 9.19% and 3.96% more than I2 during 2019 – 2020. Red corn had better contents of bio – active compounds than other two varieties during both years of the trial. The mean yield of I3 was 6.87% more than I2 in 2019 and 9.05% more than I2 in 2020 which revealed that regulated deficit irrigation might help growers to cope with decline in water availability also 25% water restriction caused tolerable decreases in grain yield and some yield compounds of the current work.

Keywords: Water scarcity, Physiology, Anthocyanins, Antioxidants, Phenolics

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Öz

Mısır üretimi kurak ve yarı kurak bölgelerde çevresel problemler ve su kıtlığının bir sonucu olarak zorlaşmaktadır. Kuraklığa dayanıklı hibritlerin ve uygun sulama rejimlerinin belirlenmesi su kıtlığı koşullarında mısır üretimini stabilize etmeye yönelik stratejilerdir. Deneme mısırda kısıtlı sulama uygulamaları ve tane rengi faktörünün bazı kalite özellikleri üzerine etkilerini belirlemek amacıyla 2019 – 2020 yetiştirme sezonlarında "Selçuk Üniversitesi, Ziraat Fakültesi, Tarla Bitkileri Bölümü, Prof. Dr. Abdulkadir AKÇIN Deneme Alanı, Konya, TÜRKİYE" de yürütülmüştür. Denemede faktör olarak sulama [Class A evaporasyon kabından gerçekleşen buharlaşmanın %50 (I1)' si, %75 (I2)' i ve %100 (I3)' ü] ve genotipler [DKC 5783, kırmızı mısır ve Sakarya] yer almıştır. DKC 5783' ün 2019 yılı I1 uygulamasında sekiz özelliğin ikisinde (bin tane ağırlığı ve tane verimi), Sakarya' nın ikisinde (total fenolik bileşenler ve tane ham yağı), kırmızı mısırın dördünde (total antosiyanin içeriği, total antioksidan aktivitesi, tane ham protein ve nişasta) en yüksek değerlere sahip oldukları, bununla birlikte kırmızı mısırın 2020 yılı I1 uygulamasında sekiz özelliğin ikisinde (total antosiyanin içeriği ve total fenolik bileşenler), Sakarya' nın ikisinde (tane ham protein ve tane ham yağ), DKC 5783' ün ise dördünde (bin tane ağırlığı, total antioksidan aktivitesi, nişasta ve tane verimi) en yüksek değerlere sahip oldukları kaydedilmiştir. 2019 – 2020 yetiştirme sezonlarının I3 uygulamasında bin tane ağırlığının I2' ye göre sırasıyla %6.71 ve %0.57 yüksek olduğu, nişasta içeriğinin ise her iki yılda da I2' ye göre %9.19 ve %3.96 yüksek bulunduğu belirlenmiştir. Kırmızı renkli mısırın biyo – aktif bileşen içeriğinin denemenin her iki yılında da diğer varyetelerden daha iyi olduğu görülmüştür. 2019 yılında I3' teki ortalama verim I2' den %6.87, 2020 de ise %9.05 yüksek bulunmuş, bu sonuçlar kısıtlı sulama uygulamalarının su kullanım etkinliğini olumlu yönde etkilediğini göstermiştir. Ayrıca %25' lik su kısıntısının mevcut çalışmada bazı verim unsurlarında tolere edilebilir kayıplar oluşturduğu izlenmiştir.

Anahtar Kelimeler: Su kıtlığı, Fizyoloji, Antosiyaninler, Antioksidanlar, Fenolikler

1. Introduction

Increasing crop productivity is necessary because of climate, rainfall changes (Nasseri, 2021) as well as population but in many countries around the world, abiotic stressors as drought cause yield loses (Soltanbeigi, 2019) and adversely affect human and animal nutrition.

In plant production, the average product loss due to biotic and abiotic stress factors varies between 65% and 87% (Kacar et al., 2009). Water stress is one of the most well – known abiotic stress factors. When usable areas in the world are classified according to stressors, water stress, which is a natural stress factor, constitutes the largest slice with a share of 26% (Blum, 1986; Kalefetoğlu and Ekmekçi, 2005).

The world' s annual precipitation average is 1000 mm, Türkiye' s is 643 mm, and Konya' s is 322 mm. Accordingly, water scarcity is a characteristic feature of Türkiye, especially Konya (Sade, 2008). Because of previous reasons, water reserves of our country must be used without waste, precautions must be taken in terms of economic usage of water resources and studies must be supported to prevent waste of water.

Being many usage areas of water resources, supports researchers to develop methods for maximum yield with minimum water consumption. Limited irrigation treatments are one of the previous methods as well. The aim of limited irrigation practices is decreasing amount of irrigation water or decreasing irrigation frequency thus increasing water use efficiency of plants. Many studies were conducted to increase water use efficiency and grain yield in arid and semi – arid regions of developed and developing countries (Igbadun et al., 2008).

Limited irrigation treatments not being supposed to affect plant growth and development in negative way. Otherwise it may cause high yield loses. Pandey et al., (2000) stated that uncontrolled water shortage during vegetative development stage causes 7% ─ 11% while during reproductive stage 23% ─ 27% yield loses. Water scarcity changes hormone synthesis, which weakens the relationship between assimilate and grain, that results in ovule sterilization and decreases the number of grains (Moosavi, 2012). Çakır (2004) reported that the maize is more tolerant to water shortage in the vegetative development period compared to other development stages, and water scarcity stress during the flowering period causes significant yield losses. According to the previous knowledge, it is important to restrict the amount of water in such a way that water use efficiency is increased while irrigation water consumption is reduced. On the contrary negative effects of water scarcity, water restriction effects plant metabolism in positive ways. The effects of deficit irrigation treatments on bio – active compounds as soluble solids, polyphenols and anthocyanins were investigated, in terms of the results deficit irrigation increased the content of bio – active compounds (Yang et al., 2022). In this study, which was carried out for two years, the effects of deficit irrigation practices and grain colour on bio – active compounds, grain quality characteristics and grain yield in maize were examined.

2. Materials and Methods

2.1. Materials

A two – year field study was conducted during 2019 and 2020 in the "Experimental Farm of Selcuk University, Agriculture Faculty, Crop Science Department", Konya, Türkiye (32°31′N, 37°52′E). The typical soil type of this area has low organic matter and poor soil fertility. The soil had a clay – loamy texture, the pH was 7.80, and the organic matter was 1.07% (**P =** 5.33 mg kg^{-1}; **B =** 0.98 mg kg^{-1}; **Cu =** 0.97 mg kg^{-1}; **Fe =** 2.84 mg kg^{-1}; **Mn =** 5.42 mg kg^{-1}; **Zn =** 1.01 mg kg^{-1}).

The Turkish State Meteorological Service provided weather data for the growing seasons of 2019 – 2020. During the growing season (April - October) of both years, we also observed greater minimum and maximum temperatures than long years; nevertheless, rain totals during both years were lower than long years (*Table 1*).

Two hybrid corns, Sakarya (*Zea mays indentata* L., originated by Turkey) and DKC 5783, are high yielding middle maturity varieties. Red corn (RC) (*Zea mays indentata* L.) has red – coloured grains, also middle maturity, and a long – term, self – pollinated population. The seeds of Sakarya and RC (red corn) were provided from "The Ministry of Agriculture and Forestry Maize Research Institute, Republic of Turkey".

Experimental design, treatments, and crop management

A field study was designed with three irrigations using drip irrigation method composed of 50% (I1), 75% (I2) and 100% (I3) of evaporation from "Class A Evaporation PAN" was applied in a randomized complete block design (RCBD) with split arrangement along with three replications.

Three factors, irrigations [I_1 (50%), I_2 (75%) and I_3 (100%)] and genotypes (Sakarya, RC, DKC 5783), were used in experiment with the main plots irrigations and the subplots being different genotypes.

Maize seeds were manually sown. The fertilizers were applied at 200 kg ha^{-1} N, 100 kg ha^{-1} P_2O_5, and 70 kg ha^{-1} pure K_2O respectively (Ayrancı and Sade, 2004; Karaşahin and Sade, 2012). The sources of fertilizers were urea (46%), diammonium phosphate (18 – 46 – 0) and potassium nitrate (13 – 0 – 46).

The P and K were applied at the time of sowing as basal fertilizer, but N was applied split in three doses. All agronomic management practices were the same during the experimental work.

Table 1. Monthly climate data during the growth period of corn in 2019 and 2020 in Konya, Turkey

Months	Temperature (°C)						Average relative humidity (%)		Total precipitation (mm)	
	Maximum		Minimum		Average					
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
April	17.00	18.10	6.40	7.80	11.10	12.60	58.50	53.30	26.40	36.40
May	26.20	24.70	1.50	11.80	19.70	18.00	39.80	46.60	5.40	36.00
June	28.90	28.20	17.60	15.90	23.00	22.00	47.20	44.40	32.60	32.80
July	30.50	33.00	18.40	20.60	24.30	26.90	39.70	35.70	9.20	-
August	30.50	31.50	19.40	19.10	24.80	25.50	40.70	33.20	2.00	7.80
September	27.40	30.70	15.10	17.70	21.00	23.90	41.30	42.60	10.40	10.40
October	23.40	25.70	12.00	12.40	17.30	18.40	49.60	47.80	6.60	12.20
Total	-	-	-	-	-	-	-	-	91.60	135.60
Mean	26.27	27.41	14.62	15.04	20.17	21.04	45.25	43.37	-	-
1929-2000	24.72		10.55		17.92		-		157.70	

The sowing pattern was 70 cm (between rows) × 20 cm (plant to plant in rows). The plants were irrigated with a drip irrigation method. Dripper (16 mm diameter) spacing of 20 cm was selected based on soil characteristics and dripper discharge. A drip irrigation system was installed in the field before sowing. Lateral pipes of 7 m long were placed in experimental plots within four plant rows and a lateral spacing of 70 cm.

As a part of the sowing process, the Class A Evaporation Pan was set up. 2019 sowing was conducted in the second week of May and 2020 sowing was conducted in the last week of April. Until the emergence in 2019, irrigation was provided (13 m^3 per subplot), and the emergence in 2020 was provided without irrigation (*Table 2*).

Table 2. Amount of irrigation water applied during all season (mm)

Irrigations	2019	2020
I1 (50%)	414.46	368.48
I2 (75%)	506.40	527.21
I3 (100%)	633.00	714.29

In order to compensate for the soil's moisture deficit, the main plots of the study were irrigated until emergence in 2019.

The amount of the irrigation water was calculated using the equation of Öktem et al., (2003):

$$I = A \; x \; Epan \; x \; Kcp \quad \text{(Eq.1)}$$

where I is the amount of irrigation water (mm), A is the plot area (m^2) and Epan (mm) is the cumulative water depth from Class A Evaporation Pan based on irrigation frequencies. Kcp is the crop pan coefficient; determined as 50% of total evaporation of Class A Evaporation Pan in the 7 – day irrigation frequency was Kcp_1 (I1), 75% was Kcp_2 (I2), and 100% was Kcp_3 (I3) (Demirok and Tuylu, 2019; Öktem et al., 2003; Şahin and Al-Bayati, 2018). The trial area was irrigated for ten times in both years of the trial (except the irrigations until emergence). The irrigation was started in 24.06.2019 and 28.05.2020 while it finished in 10.09.2019 and in 14.09.2020.

2.2. Methods

The following analysis were performed with the grain samples obtained from each sub – plot in both growing seasons.

Thousand grain weight: Thousand grain weight was determined according to Tezel (2007) by counting 400 grains three times and weighing them.

Total antioxidant activity: Radical supressing activities of antioxidants were measured from the bleaching rate of methanol solution of DPPH (2,2-diphenyl-1-picrylhydrazyl) (Khampas et al., 2013). A 4.5 mL DPPH solution was added to the 0.5 mL phenolic extract. The mixture was mixed and left to stand for 30 min in unlit conditions. The absorbances of the samples were determined at 517 nm against solvent blank.

The rate of DPPH radical scavenging was calculated using the following formula:

$$Scavanging\ rate\ = \left[\frac{(A_0\ - A_1)}{A_0}\right]\ \times 100 \qquad \text{(Eq.2)}$$

where A_0 is the absorbance of the control (0.5 mL extraction solvent with 4.5 mL DPPH solution) and A_1 is the absorbance in the presence of phenolic extract solutions.

Total anthocyanin content: Total anthocyanin content of maize grains were determined according to Cervilla et al., (2012). 0.1 g of grain sample was homogenized with 5 ml of propanol and HCl solution. The homogenate was centrifuged at 5000 rpm, afterwards left at room conditions for 24 hours then centrifuged at 6500 rpm again. After the centrifuge, the absorbances of the samples were determined in the range of 535 – 650 nm. The obtained values were adapted to the following formula and recorded as the TAC of maize grains.

Finally, the results were calculated and the absorbances corrected at 535 – 650 nm using the formula below:

$$A = A_{535} - \ A_{650} \qquad \text{(Eq. 3)}$$

Total phenolic compounds: Total phenolic compounds were determined according to Mohsen and Ammar (2009) with spectrophotometry by using gallic acid standard.

Starch: Grain starch content was detected according to Alan et al., (2014) by determining optical degree of rotation with polarimeter. Starch content was determined by the formula using previous values and recorded as % starch.

Crude grain protein: Crude grain protein content of the grains were determined according to Özdemir and Sade (2020a).

Crude grain oil: Crude grain oil content was determined according Özdemir and Sade (2019a) and recorded as % crude grain oil.

Grain yield: After the physiological maturity, all cobs of four rows were taken from each sub – plot to discover grain yield (kg da^{-1}) at 15% moisture content according to Özdemir and Sade (2019b).

All values in the tables are means. All data was analysed by MSTAT – C statistical analysis programme. Means were grouped in terms of LSD multiple range test ($P \leq 0.05$).

3. Results and Discussion

Variance analysis results, mean values and LSD groups of TGW that were detected in different genotypes under deficit irrigation conditions during 2019 and 2020 growing seasons were presented at *Table 3 – 4* and *Figure 1A – 2A.*

Table 3. Variance analysis results of TGW (thousand grain weight, g), TAC (total anthocyanin content, mg kg $^{-1}$ C3G), TAA (total antioxidant activity, %), TPC (total phenolic compounds, mg 100 g^{-1} GAE), GCO (grain crude oil, %), GCP (grain crude protein, %), starch (%) and grain yield (kg da^{-1}) properties in 2019

VS	DF	TGW	TAC	TAA	TPC	GCO	GCP	Starch	Grain Yield
Replication	2	444.11	0.11	0.12	17.24	3.89	0.46	45.54	14267.96
Irrigation (I)	2	24459.46**	23.94**	2.62	200.42**	4.69	11.00**	481.55**	211933.97**
Error	4	2747.45	0.22	1.33	26.81	2.05	0.11	57.90	13178.87
Genotype (G)	2	15994.24**	292.65**	153.59**	1811.67**	2.68	21.12**	160.25**	1615602.14**
I × G	4	2283.96	12.03**	21.77**	710.05**	3.66	1.95*	304.42**	24279.41
Error	12	5083.12	0.80	4.79	60.40	4.59	1.77	79.95	106809.134
Total	26	51012.36	329.78	184.25	2826.61	21.58	36.42	1129.63	1986071.49
CV (%)		7.20	4.63	4.31	3.50	16.75	6.00	3.78	10.91

VS (variation of source) *p≤0.05; **p≤0.01

While effects of irrigations on TGW were investigated it was observed that values increased in parallel water supply during both years of the experiment therewithal means in 2020 were higher than 2019. Tolerable decreases were observed under I2 in accordance I3, such that mean TGW under I3 during 2019 was 6.71% higher than I2. Similarly, TGW under I3 was 0.60% higher than I2 during 2020. Remarkable variations were observed in both years of the experiment according to genotypes as well, such that the highest TGW was obtained from DKC 5783, and it was followed by RC and Sakarya respectively. As a result, DKC 5783 maintained its superiority in TGW during both years of the experiment. Durmuş et al., (2015) stated that limited irrigation decreased TGW of maize and the means were obtained from the deficit irrigation treatments ranged between 286.40 g – 312.00 g while TGW of full irrigation ranged between 285.90 – 361.00 g. Similarly NeSmith and Ritchie (1992) reported that TGW of maize decreased in parallel water restriction. Karam et al., (2003) also stated that deficit irrigation decreased TGW nearby 18.00%. Variance analysis results, mean values and LSD groups of TAC that were detected in different genotypes under deficit irrigation conditions during 2019 and 2020 growing seasons were presented at *Table 3 – 4* and *Figure 1B – 2B*. While effects of limited irrigation on TAC were investigated it was observed that TAC increased in parallel water supply, in accordance previous detection the highest value of the group was obtained from I3. Unlike previous year in 2020, TAC values from I1 and I3 were close to each other whilst the highest value was obtained from I2. While means of TAC were investigated according to varieties it was observed that RC had highest TAC in both years of the experiment whilst TAC of other genotypes was close to each other. Statistically significant variations were observed in I × G interaction during both years of the experiment in terms of TAC and the highest value of I1 was obtained from RC. Žilić et al., (2012) determined TAC among 2.50 mg kg^{-1} C3G and 696.00 mg kg^{-1} C3G while Özdemir and Sade (2020b) analysed TAC among 1.19 mg kg^{-1} C3G – 306.90 mg kg^{-1} C3G in maize grains. Results of the current study are compatible with the previous detections as well.

Table 4. Variance analysis results of TGW (thousand grain weight, g), TAC (total anthocyanin content, mg kg $^{-1}$ C3G), TAA (total antioxidant activity, %), TPC (total phenolic compounds, mg 100 g^{-1} GAE), GCO (grain crude oil, %), GCP (grain crude protein, %), starch (%) and grain yield (kg da^{-1}) properties in 2020

VS	DF	TGW	TAC	TAA	TPC	GCO	GCP	Starch	Grain Yield
Replication	2	1473.23	0.60	16.33	277.31	0.21	0.02	10.95	9595.40
Irrigation (I)	2	28469.87**	1.98**	39.64	344.78	5.85	0.56**	343.49**	568314.18*
Error	4	2224.83	0.08	23.41	130.69	3.02	0.04	25.67	81880.91
Genotype (G)	2	9351.96*	203.35**	1.97	1478.98**	1.13	12.19**	85.94**	1051691.36**
I × G	4	2622.86	8.91**	131.39**	1142.82**	1.91	8.66**	325.77**	86129.02
Error	12	10537.96	1.06	61.41	302.07	3.29	0.59	41.23	205450.22
Total	26	54680.73	216.00	274.18	3676.67	15.44	22.08	833.07	2003061.11
CV (%)		9.23	7.85	12.75	7.66	11.96	4.12	2.69	14.44

VS (variation of source)
*p≤0.05; **p≤0.01

Variance analysis results, mean values and LSD groups of TAA that were detected in different genotypes under deficit irrigation conditions during 2019 and 2020 growing seasons were presented at *Table 3 – 4* and *Figure 1C*

– *2C*. Red corn was the genotype with the highest TAA in 2019 and followed by Sakarya and DKC 5783 respectively. In accordance previous detections RC was the genotype with the highest TAA under I1. Unlike 2019, the highest TAA was obtained from I1 × DKC 5783 in 2020 and significant variations were not observed among irrigations and genotypes. Oladeji et al., (2017) reported that TAA of maize grains ranged between 11.38% ─ 20.70%. Results of the current study are compatible with the previous knowledge. It was observed that RC -which is anthocyanins rich in genotype- is also rich in antioxidants as expected.

Variance analysis results, mean values and LSD groups of TPC that were detected in different genotypes under deficit irrigation conditions during 2019 and 2020 growing seasons were presented at *Table 3 – 4* and *Figure 1D – 2D*. While TPC values of maize grains were investigated it was observed that RC had higher TPC than other two genotypes during both years of the experiment. The highest TPC in 2019 was obtained from I3, on the contrary the highest TPC of 2020 was from I1. While means of S × G were investigated during 2019 it was observed that Sakarya and RC had higher TPC whilst RC and DKC 5783 had higher TPC than Sakarya during 2020. Bacchetti et al., (2013) stated that they determined TPC in maize flour between 115.40 mg 100 g^{-1} GAE ─ 175.50 mg 100 g^{-1} GAE, while Özdemir and Sade (2020b) between 30.35 mg 100 g^{-1} GAE – 47.76 mg 100 g^{-1} GAE. The results of the current study are also compatible with the previous knowledge as well.

Variance analysis results, mean values and LSD groups of GCP that were detected in different genotypes under deficit irrigation conditions during 2019 and 2020 growing seasons were presented at *Table 3 – 4* and *Figure 1F – 2F*. Grain crude protein content decreased because of increasing irrigation water and the highest GCP values were obtained from I1 treatment in both years of the trial. While means of GCP investigated in terms of genotypes, it was detected that RC had highest GCP in both years of the experiment. In parallel previous year, during 2019 the highest GCP was obtained from I1 × RC as well while the highest GCP was detected from I1 × Sakarya during 2020. In the literature, there are studies in which include findings that limited irrigation practices increase grain protein concentration (Anjum et al., 2017; Hafızoğlu, 2020).

Variance analysis results, mean values and LSD groups of starch content that were detected in different genotypes under deficit irrigation conditions during 2019 and 2020 growing seasons were presented at *Table 3 – 4* and *Figure 1G – 2G*. While effects of deficit irrigation on starch content was investigated it was observed that starch content induced in terms of increasing water supply. The highest starch content was reached in I3 in both years of the experiment and followed by I2 and I1 applications, respectively. While means of I × G interaction were investigated in 2019 it was seen that the highest starch values were obtained from the genotype RC whereas DKC 5783 had the highest starch content under I1 during 2020, thus RC could not maintain its superiority in the second growing season. In terms of the results of the current work water restriction decreased starch content of maize. Mohammedkhani and Heidari (2008) stated that water scarcity may decrease grain starch content of maize too.

The highest grain yield determined in I3 and I2 of DKC 5783, respectively; and I3 was 6.87% higher than I2 during 2019 (n = 3) (*Table 3 – 4*, *Figure 1H – 2H*). The grain yield from I3 and I2 of Sakarya were close to DKC 5783. Both, Sakarya and DKC 5783, had the lowest grain yield under I1 therewithal DKC 5783 had 7.77% more grain yield than Sakarya (n = 3). Similar yield changes were detected among the treatments of RC as other genotypes such that the highest value was from I3 and followed by I2 and I1 (n = 3). The highest grain yield was from I3 and followed by I2 and I1, respectively during 2020 (n = 9). The grain yield of I3 was 9.05% higher than I2, whereas 48.36% higher than I1. A remarkable difference was also observed among the genotypes (n = 9). The highest mean of the current property was from DKC 5783, followed by Sakarya and RC. The yield of DKC 5783 was 27.82% more than Sakarya and 72.45% greater than RC.

Some studies declared that corn tolerates deficit irrigation with no significant yield loss (Igbadun et al., 2008) nevertheless Desoky et al., (2021) reported that the yield contributing properties like PH, grain number per kernel, thousand – grain weight decrease due to water shortage. Moharramnejad et al., (2019) also postulated that water stress is harmful for crop growth and yield; it was opined that floret abortion because of water scarcity caused lower cob weight, lower grain weight, and yield as a result the crop did not produce more effective florets per flower (Halli et al., 2021). The yield loss effects of irrigation shortage were observed in the current study, like previous literature. DKC 5783 was the most notable genotype with its highest yield values in all treatments, followed by Sakarya and RC.

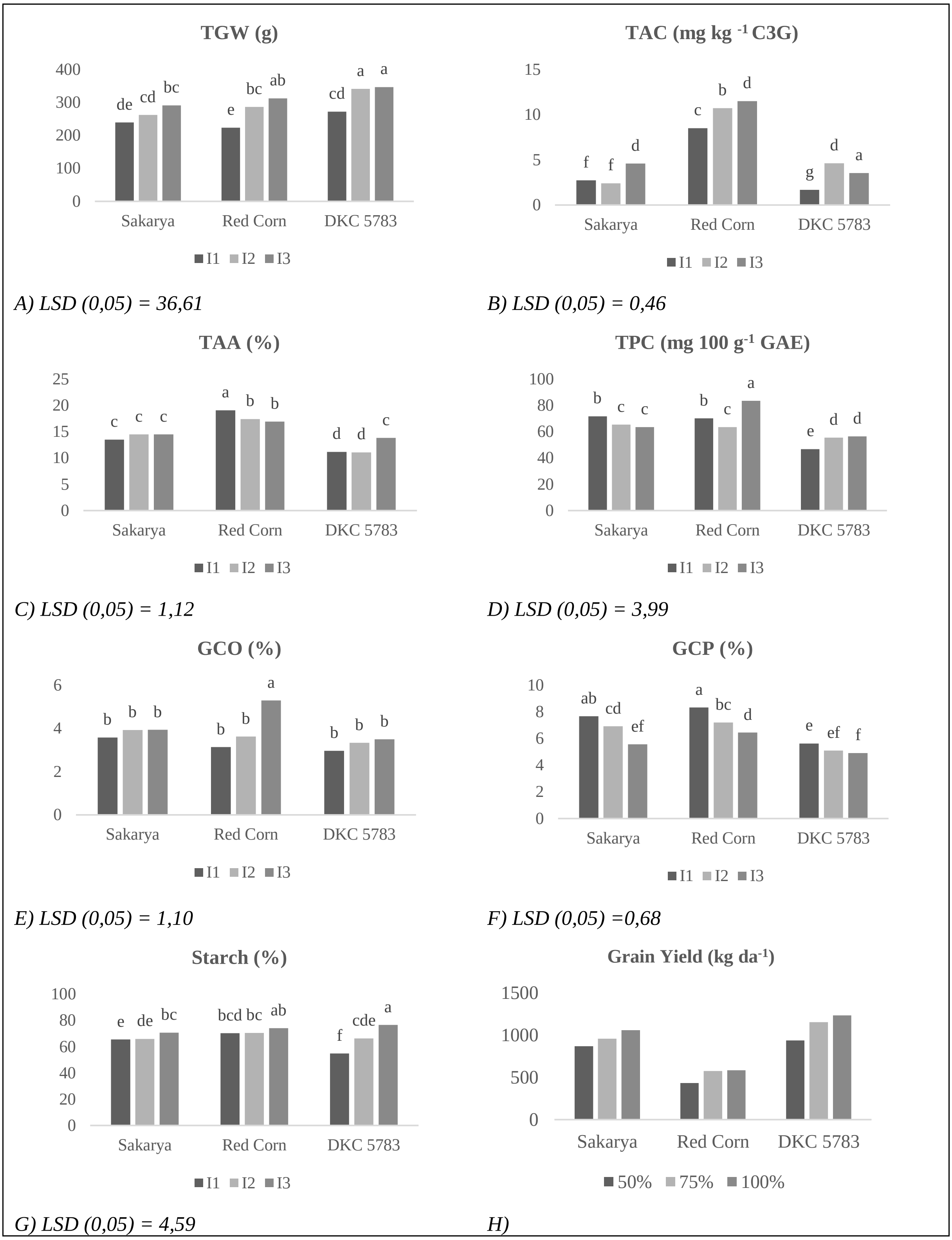

Figure 1. Means of TGW (thousand grain weight), TAC (total anthocyanin content), TAA (total antioxidant activity), TPC (total phenolic compounds), GCO (grain crude oil), GCP (grain crude protein), starch and grain yield properties in 2019; I1 is 50%, I2 is 75% and I3 is 100% of total evaporation of Class A Evaporation PAN.

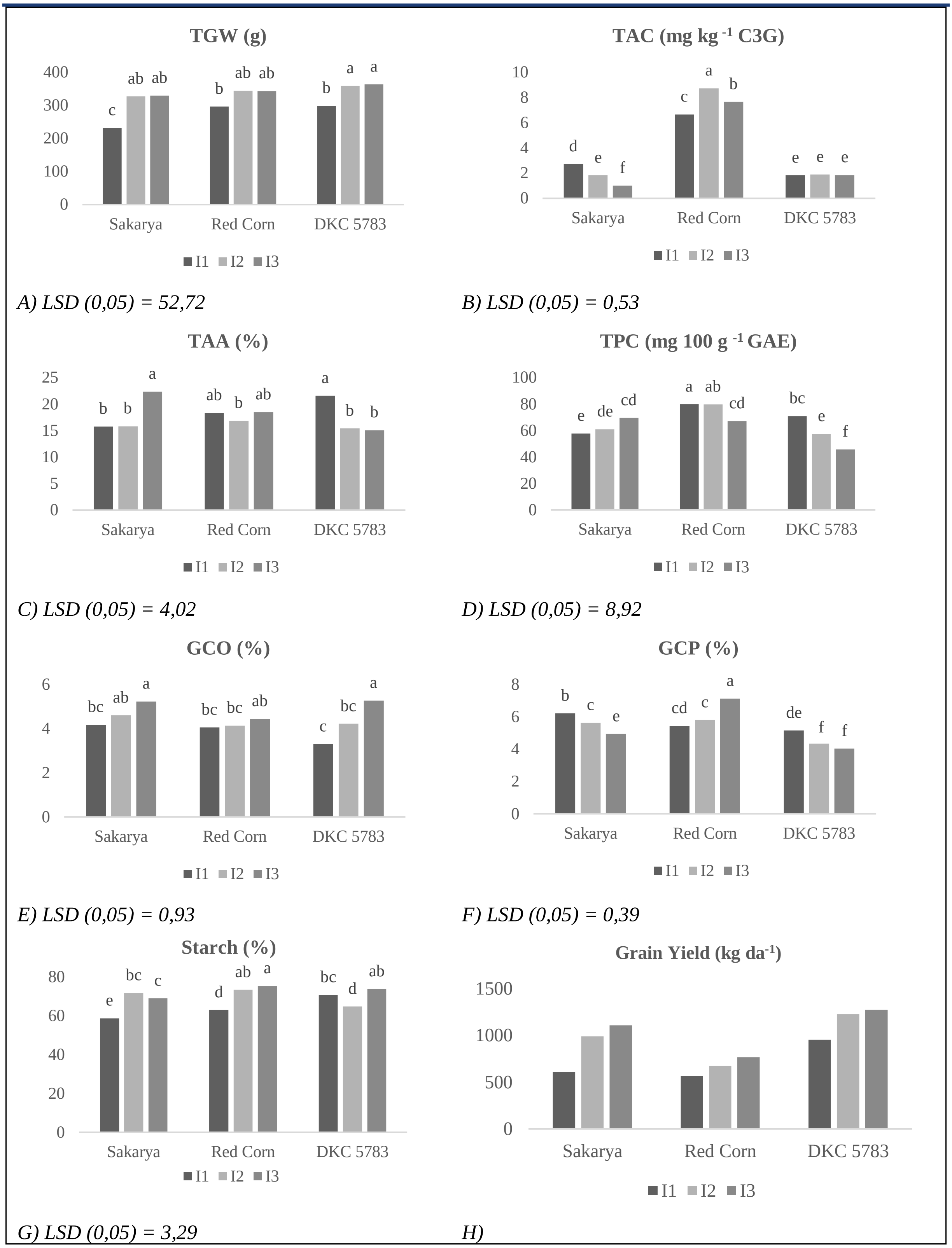

Figure 2. Means of TGW (thousand grain weight), TAC (total anthocyanin content), TAA (total antioxidant activity), TPC (total phenolic compounds), GCO (grain crude oil), GCP (grain crude protein), starch and grain yield properties in 2020; I1 is 50%, I2 is 75% and I3 is 100% of total evaporation of Class A Evaporation PAN.

4. Conclusions

The aim of the current work was to determine effects of deficit irrigation and grain colour on quality traits of maize like TGW, TAA, TAC, TPC, starch, CGP and CGO. According to the results, water shortage -particularly I1- negatively affected quality traits while I2 caused tolerable declines. The results of the experiment showed that limited irrigation in Konya basin can significantly contribute to water saving with satisfactory grain yield in corn farming areas. DKC 5783 was ahead of the other two genotypes in terms of grain yield. Red corn ranked last in yield. It is opined that the most important reason of RC not to be reached high yield values is, it's being a population. Colour factor was also effective especially on bio – active compounds such that RC had more amount of bio – active content than other two varieties during both years of the trial thus may be an alternative genotype under limited irrigation conditions, also 25% water restriction caused tolerable decreases in some yield compounds of the current work.

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Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

Conflicts of Interest

There is no conflict of interest between the article authors.

Authorship Contribution Statement

Concept: Özdemir, E., Sade, B.; Design: Özdemir, E., Sade, B.; Data Collection or Processing: Özdemir, E.; Statistical Analyses: Özdemir, E., Sade, B.; Literature Search: Özdemir, E.; Writing, Review and Editing: Özdemir, E., Sade, B.

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