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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

Determination of Yield and Quality of Different Snap Bean Varieties Under Deficit Irrigation

Farklı Yeşil Fasulye Çeşitlerinin Kısıtlı Sulama Altında Verim ve Kalitesinin Belirlenmesi

Sinan SÜHERİ[1*], Noor Muqdad HUSSEIN HUSSEIN[2], Ertan Sait KURTAR[3], Nurcan YAVUZ[4], Yeşim DAL[5]

Abstract

In the Konya region, snap bean requires frequent irrigation due to high evaporation and low precipitation during the growing season. However the drought in recent years at Turkey, especially in Konya plain has been one of the most important abiotic stress factor affecting the snap bean production. Several ways to reduce yield losses are deficit irrigation practices, to improve and disseminate the varieties that are tolerant to water stress.

In this research, the response of two green bean varieties one of which was improved by Prof. Dr. Önder Türkmen, Horticulture Department of Agriculture Faculty of Selcuk University (S3) and a commercial variety existing in Turkey market (Nazende) to different irrigation water levels under drip irrigation has been investigated. The irrigation treatments included five irrigation water level according the amount of water evaporated from Class-A Pan within 7 days period and based on 5 different crop pan coefficients (kcp1= 1.25; kcp2= 1.00, kcp3= 0.75, kcp4= 0.50 ve kcp5= 0.00) .

According to the results, it was found that there were significant differences in yield, pod length, pod width, pod thickness and seed per pod among irrigation levels. No significant differences were observed in yield, pod thickness among varieties. The seasonal water use of the snap bean were ranged from 177 mm to 635 mm for Nazende, 181 mm to 655 for S3. The highest yield was obtained in kcp2 treatment with 3762 kg ha-1 for S3 and kcp1 treatment with 3525.0 kg ha^{-1} for Nazende. It was not observed significant differences in yield between kcp1, kcp2, kcp3 treatment for both genotypes. Linear relations were found between yield and seasonal water use. The yield response factors (ky) were found 1.24 for both varieties. No differences were observed for pod colour values (L, a, b) among irrigation levels.

Keywords: Fresh bean, Irrigation, Color, Semi-arit, Cultivar

Öz

Taze fasulye yetiştirme sezonu boyunca Konya bölgesinde yüksek buharlaşma değerlerinden dolayı sık sulamaya ihtiyaç duyulmaktadır. Türkiye'de özellikle Konya bölgesindeki kuraklık taze fasulye üretimini etkileyen en önemli abiyotik stres faktörü olmuştur. Kısıtlı sulama ve kuraklığa toleranslı çeşitlerin yetiştirilmesi verim kayıplarını önlemenin yollarından biridir.

[1*]**Sorumlu Yazar/Corresponding Author:** Sinan Süheri, Selçuk Üniversitesi Ziraat Fakültesi Tarımsal Yapılar ve Sulama Bölümü Konya/TURKEY E-mail: ssuheri@selcuk.edu.tr OrcID: 0000-0002-6163-0706
[2] Noor Muqdad Hussein Hussein, Selçuk Üniversitesi Ziraat Fakültesi Tarımsal Yapılar ve Sulama Bölümü Konya/TURKEY. E-mail: nurhussin920@gmail.com OrcID: 0000-0003-1051-901X.
[3] Ertan Sait Kurtar, Selçuk Üniversitesi Ziraat Fakültesi Bahçe Bitkileri Bölümü Konya/TURKEY. E-mail: ertansaitkurtar@selcuk.edu.tr OrcID: 0000-0002-7203-7430.
[4] Nurcan Yavuz, Selçuk Üniversitesi Ziraat Fakültesi Tarımsal Yapılar ve Sulama Bölümü Konya/TURKEY E-mail: ncivicioglu@selcuk.edu.tr OrcID: 0000-0003-1833-0668
[5] Yeşim Dal, Selçuk Üniversitesi Ziraat Fakültesi Bahçe Bitkileri Bölümü Konya/TURKEY. E-mail: yeşim.dal@selcuk.edu.tr OrcID: 0000-0002-3806-6465.
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Bu çalışmada Selçuk Üniversitesi Ziraat Fakültesi Bahçe Bitkileri Bölümü öğretim üyesi Prof. Dr. Önder Türkmen tarafından geliştirilen bir taze fasulye genotipi (S3) ile Türkiye'de taze fasulye tohum pazarında bulunan Nazende çeşidinin farklı sulama seviyelerine olan tepkileri araştırılmıştır. Sulama suyu seviyeleri A-Sınıfı Buharlaşma kabından 7 günlük aralıklara olan yığışımlı buharlaşmanın oranları şeklinde (kcp1= 1.25; kcp2= 1.00, kcp3= 0.75, kcp4= 0.50 ve kcp5= 0.00) oluşturulmuştur.

Araştırma sonuçlarına göre, sulama seviyeleri arasında taze fasulye verimi, bakla uzunluğu, bakla eti kalınlığı ve bakladaki tohum sayısı yönünden istatistiki olarak önemli farklar bulunmuştur. Taze fasulye verimi ve bakla kalınlığı yönünden ise çeşitler arasında bir fark gözlenmemiştir. Taze fasulyenin mevsimlik su tüketimi deneme konularına göre Nazende çeşidi için 177 mm ile 635 mm arasında, S3 genotipi için ise 181 mm ile 655 mm arasında değişmiştir. En yüksek verim S3 genotipi için kcp2 konusundan 3762 kg ha^{-1}, Nazende çeşidi için ise 3525 kg ha-1 ile kcp1 konusundan elde edilmiştir. Sezonluk bitki su tüketimi ve verim arasında doğrusal ilişkiler bulunmuştur. Verim tepki etmeni Nazende ve S3 için 1.24 olarak hesaplanmıştır. Bakla renk değerleri (L, a, b) açısından sulama seviyeleri arasında önemli bir fark bulunmamıştır.

Anahtar Kelimeler: Taze Fasulye, Sulama, Renk, Yarı Kurak, Çeşit

The beans are the important nutrition sources for human and consumed as fresh, dry or canned. It is rich in protein, phosphorus, iron and vitamin B. Due to its high nutritional and economic value; it is regarded as one of the world's most important vegetable for human consumptions. 65.2% of human protein needs in the worlds are provided from plant sources (Grigg, 1995). The grains and pulses provide 43% and 23% of protein needs of human in the world. The researchers have reported that beans are an important protein source for developing countries (Weissenbacher, 2009).

According to TUIK (Turkish Statistical Institute) dry bean production is about 240 thousand tones from about 100 thousand hectares while snap bean production is about 640 thousand tones from 60 thousand hectares. Turkey ranks the third after China and Indonesia in snap bean production. Therefore, snap bean production is important for the country.

Although; Turkey has an important place in snap bean production, the research related with bean breeding is inadequate compared to the other countries in the world.

The bean varieties cultivated in Turkey are selected or improved according to their performance under irrigated conditions considering their characteristics such as yield and diseases resistance regardless of their water consumptions. Snap beans in Turkey, especially in the Konya region, require frequent irrigation due to high evaporation and low precipitation during the growing season. However the drought in recent years at Turkey, especially in Konya plain has been one of the most important abiotic stress factor affecting the snap bean production. The several ways to reduce yield losses under drought condition and to increase water use efficiency are deficit irrigation practices, to improve and disseminate the varieties that are tolerant to water stress.

Water management is crucial for both dry and snap bean production in the regions especially where water resources are limited. Several researchers who have attempted to investigate the effect of irrigation regimes on dry and snap bean yield in Konya, reported that the highest yield obtained when 0.58 – 1.38 m^3 of water were applied for per kg dry bean seed. (Bahçeci, 1995; Özbahçe, 2008; Topak et al.,, 2011a; Yurteri & Topak, 2017) and the highest yield obtained when 0.15– 0.16 m^3 of water were applied for per kg snap bean yield (Husein, 2018; Topak & Albayati, 2018).

The amounts of water applied to get highest yield for per kg of several crops are 0.12 m^3 for potato (Yavuz et al., 2016a), 1.26 m^3 for sunflower (Yavuz et al., 2016b), 0.07 – 0.12 m^3 for sugar beet (Süheri, 2007; Tari, 2016a; Topak et al., 2011b), 0.66 for wheat (Tari, 2016b), 0.37 for maize (Karaşahin & Sade, 2011) in Konya and 12.10 m^3 for pepper in Çanakkale (Demirel et al., 2012) 6.86 m^3 for eggplant in Tekirdağ (Yenigün & Erdem, 2019). When the amounts of water applied to get highest yield for per kg of the vegetable crops considered, snap beans needs considerably higher water in Konya region.

In this research, the response of the two green bean genotypes to different irrigation water levels under drip irrigation was investigated and compared according to their water consumption, yield and some yield components.

Materials and Methods

The field experiment was conducted in Selcuk University Agricultural Faculty Research and Practice Farm located in Konya, Turkey, latitude 36° 06′ and longitude 32°36′ mean altitude 1007 m above sea level, during the growing season of 2017 between the months April and September. The satellite image of the research area has shown on *Figure 1*.

Figure 1. Research Area

Konya where the research was conducted has arid climatic conditions with hot and dry summers. According to long term meteorological data (1929 – 2017), annual mean temperature, annual mean evaporation, annual mean

precipitation are 11.6 °C, 1324 mm and 322.4 mm respectively. Most of the precipitation is received on May and December. Minimum temperature is -28.2 °C recorded on 1942 and maximum temperature is 40.6 recorded on 2000. The meteorological data of experimental area during 2017 and long-term averages (1958 – 2017) were given Table 1.

Table 1. Meteorological Data of Experimental Area During 2017 and Long –Term Averages (1958 – 2017)

Months	Years	Mean Temperature (°C)	Mean Wind Speed (m s^{-1})	Mean Relative Humidity (%)	Precipitation (mm)
May	2017	14.7	2.9	62.5	36.2
	56 years	15.7	2.2	55.9	44.3
June	2017	19.6	3.0	61.2	43.8
	56 years	20.1	2.5	48.4	23.9
July	2017	24.4	3.6	39.2	0.0
	56 years	23.4	2.8	42.1	6.5
Agust	2017	23.5	3.8	51.2	13.9
	56 years	22.8	2.6	42.9	5.4
September	2017	21.8	3.1	37.7	3.9
	56 years	18.4	2.1	48.0	12.9

The soil of the study area has silty-clay texture. The bulk density of soil was changed 1.37g cm^{-3} to 1.26 g cm^{-3} in depth of 120 cm soil profile. The available water holding capacity of the soil was 125.1 mm in 75 cm soil profile which is the effective root depth of the snap bean. Several physical and chemical properties of the soil were given in Table 2. According to soil analysis, the plots were fertilized with a compound fertilizer DAP (18%N, 46%P) at the rate of 0.2 ton ha^{-1} before planting and ammonium nitrate (33%N) at the rate of 0.05 ton ha^{-1} on 5 July. The seeds were planted on 11 May 2017. The pods were harvested on the dates 21 July, 3, 14, 22, 28 Agust and 5, 11 Semptember 2017.

Table 2. Some Physical Properties of the Soil in The Research Area

Soil Depth (cm)	pH	Organic Matter (%)	Soil Texture	Bulk Density (g cm^{-3})	Field Capacity (*FC*)		Soil Moisture (*WP*)		Available Water (AW)	
					m^3m^{-3}	mm	m^3m^{-3}	mm	m^3m^{-3}	mm
0-30	7.78	1.65	Silty Clay	1.37	0.403	120.9	0.242	72.6	0.160	48.3
30-60	7.83	1.56	Silty Clay	1.28	0.420	126.0	0.249	74.7	0.156	51.3
60-90	8.02	0.90	Silty Clay	1.26	0.428	128.4	0.258	77.4	0.180	51.0
			Total (0-75cm)			311.1		186.0		125.1

The experiment was design in a randomized block factorial design consisting of combination of two green bean genotypes (one of which was improved by Prof. Dr. Onder Turkmen, Horticultural Department of Selcuk University Agricultural Faculty, S3 and the other one is a commercial variety existing in Turkey market, Nazende) and five irrigation level according the amount of water evaporated from Class A Pan within 7 days period and based on 5 different pan coefficient (kcp1= 1.25, kcp2=1.00, kcp3=0.75, kcp4=0.50 and kcp5=0).

Irrigation water was supplied from the deep well near the experimental area. The pH and electrical conductivity of the irrigation water were 7.6 and 1.250 ds m^{-1} respectively.

The seeds were planted manually. Row spacing was 45 cm and plant spacing was 15 cm. Plot size was 9 m^2 (5 m x 1.80 m) including 4 plant rows. To prevent each plot from other plots irrigation treatments, 2.00 m space between plots and 3 m space between blocks were left.

The plots were irrigated with drip irrigation. Drip lines 16 mm in diameter were placed to each plant rows. Dripping points were 33 cm apart with a flow rate 4 l h^{-1} at two bars pressure. The applied water to each plot was measured with flow meter. The effective root depth of snap bean was taken as 75 cm (Doorenbos and Pruit, 1977). The pods were harvested 7 times when the pods were matured. At the end of growing season, weights of harvested pods were summed

and the yield for per plant was calculated. The calculated yield for per plant was converted to 1000 square meter. Central two rows were harvested and outer rows were omitted to consider the side effects.

10 pods were collected from each plot on 3 August. Physical properties such as pod length, width, seed number per pod and pod thickness were measured on these pods. Color analyses were performed on 5 of which 10 pod samples. Skin colours of pods were measured by a CR-400 colorimeter (Konica Minolta, Ramsey, NJ) and measurements recorded as L (Lightness), a (red index) and b (yellow index) values.

The amounts of water applied in the irrigation treatments were determined using Class A pan evaporation according to Equation (1) below (Kanber, 1984; Ertek, 2011).

$$I = Ep \times Kcp \times A \qquad \text{(Eq.1).}$$

where, *Ep* is the cumulative pan evaporation measured during an irrigation period of 7 days using a standard Class A Pan (mm) *Kcp* is the coefficient of crop pan evaporation and A is the plot area (m^2). The crop water use (ET) was estimated based on a water balance equation as $ET=I+R-Dp \pm \Delta S$ where, *ET* is the evapotranspiration value (mm), *I* is the amount of irrigation water (mm), *Dp* is deep percolation (mm) and ΔS is the change in soil water stored in the plant rooting zone at growing season. Before and after every irrigation, soil water content was determined by gravimetric method on 0-30, 30-60, 60-90 ve 90-120 cm soil depths.

Water use efficiency (WUE) and irrigation water use efficiency (IWUE) was calculated as snap bean yield divided by seasonal ET and total seasonal irrigation water applied, respectively. The relationship between water use and yield was calculated according to Stewart model by using formula given below.

$$\left[1-\frac{Ya}{Ym}\right] = ky \cdot \left[1-\frac{ETa}{ETm}\right] \qquad (2)$$

Where Ya is actual yield (t ha^{-1}), Ym is the maximum yield (t ha^{-1}), ETa is the actual crop water consumption (mm), ETm is the maximum crop water consumption (mm) and ky is yield response factor.

The data collected from the treatments were evaluated by analysis of variance. The mean values were compared using Duncan's multiple range test at P<5% to determine the differences among treatments.

3. Results and Discussion

The applied irrigation water to treatments was calculated considering cumulative evaporation from Class a Pan and plant-pan coefficient within 7 days period. First irrigation and last irrigation were applied on 3 July and 9 September respectively. In total, seven irrigation treatments were performed during experimental period. Total irrigation and seasonal evapotranspiration values were indicated on Table 3. 30 mm of irrigation water was applied to all treatment for good plant establishment. The total irrigation applied to the treatments were ranged between 30 mm and 720 mm. Maximum deep percolation was occurred as 146 mm on Kcp1 treatment and no deep percolation was observed on Kcp3, Kcp4, Kcp5 treatments.

Table 3. Net and Total Irrigation and Seasonal Evapotranspiration of Varieties

Genotypes	Treatments	Total Irrigation Water (mm)*	Effective Rain (mm)	ΔS (mm)	Deep Percolation (mm)	Seasonal Evapotranspiration (mm)
Nazende	Kcp_1	720	87	-20	152	635
	Kcp_2	581	87	12	88	592
	Kcp_3	444	87	42	0	573
	Kcp_4	308	87	50	0	445
	Kcp_5	30	87	60	0	177
S3	Kcp_1	720	87	-12	140	655
	Kcp_2	581	87	18	74	612
	Kcp_3	444	87	32	0	563
	Kcp_4	308	87	60	0	455
	Kcp_5	30	87	64	0	181

ΔS:Soil moisture change between planting and harvesting (0-75 cm)

Net and total irrigation and seasonal evapotranspiration of varieties were given in Table 3. The highest ET for S3 and Nazende variety were measured as 655 mm and 635 mm on Kcp1 treatment respectively.. The evapotranspiration was increased with increasing of kcp coefficient. Several researcher who conducted their experiment under field condition have calculated highest evapotranspiration of snap bean as 299 mm in Bangalore (Hegde & Srinivas, 1990), 338mm in Tarsus (Sezen et al, 2005), 458 mm in Kahramanmaraş (Kazlı, 2005), 470 mm in Kahramanmaraş (Gençoğlan et al., 2006), 400 mm in Tarsus (Sezen et al, 2008), 804 mm in Çanakkale (Çamoğlu & Genç, 2013), 342mm in Ismailia (Marzouk et al., 2016), 840 mm in Ankara (Köksal et al., 2015), 489 mm in Konya (Albayati, 2018). In this study, highest ET was obtained as 677 mm. ET depends upon weather parameters, crop characteristics, environmental aspects and management factors (Allen et al., 1998). The differences in regions, plant varieties etc. included in previous studies have led to difference between ET calculated in this study and ET reported in previous studies. Albayati (2018) conducted irrigation experiment with Nazende variety under similar weather conditions with this study during 2017 growing seasons. The highest ET (677 mm) of the Nazende variety in this study was higher than ET (489 mm) calculated in the study conducted by Albayati (2018). However, higher yield was obtained against the higher ET in this study.

The snap bean yields were given in Table 4. There was no significant difference between two snap bean varieties in terms of yield. But significant relation between irrigation treatments and yield were found. For both varieties, the irrigation treatments of which pan coefficients are 1.25, 1.00 and 0.75 were included in same statistical group. The irrigation water applied to kcp3 treatment was 38% lower than kcp1 treatment. . It was concluded that the reduction in irrigation water amount can be expected in Konya. For Nazende snap bean variety, maximum mean yield 35.250 kg ha^{-1} was obtained from the treatment kcp1 in which highest irrigation water applied. But for S3 variety the maximum mean yield 37622 kg ha^{-1} was obtained from the treatment kcp2 where pan coefficient is 1.00. Similar trend was declared by Hegde & Srinivas (1990), Saleh et al. (2018), Bonano & Mack (1983) and Köksal et al. (2010). It was concluded that maximum irrigation water doesn't mean the maximum yields for several varieties.

Table 4. Snap Bean Yields

Treatments	Yield (kg ha^{-1})		Mean**
	Nazende	S3	
Kcp_1	35250	35807	35528a
Kcp_2	34757	37620	36188a
Kcp_3	34800	31533	33167a
Kcp_4	21247	24480	22863b
Kcp_5	3273	3250	3262c
Mean	25865.4a	26538.0a	

**p<0.01

Minimum yields were obtained as 3273 kg ha^{-1} and 3250 kg ha^{-1} from the non irrigated treatment for both varieties. There were no differences in yield among varieties in this study. This results agree with Bonano and Mack (1983) who reported that there was no difference in yield between two varieties included in their study under adequate irrigation and disagree with and El-Noemani et al. (2010), Marzouk et al. (2016) and Saleh et al. (2018) who have reported significant difference in yield among varieties included in their study under different irrigation treatments. Seymen et al. (2010) reported that the differences in snap bean yield might be referred to genetic diversity of the varieties. S3 is newly improved variety and doesn't exist in Turkish market yet. The fact that there is no difference in yield Nazende and S3 proves that S3 has a market potential in Turkey.

Significant polynomial relationships were found between total irrigation water applied and snap bean yield and linear relationships were found between ET and snap bean yield for both varieties as shown in Figure 2.

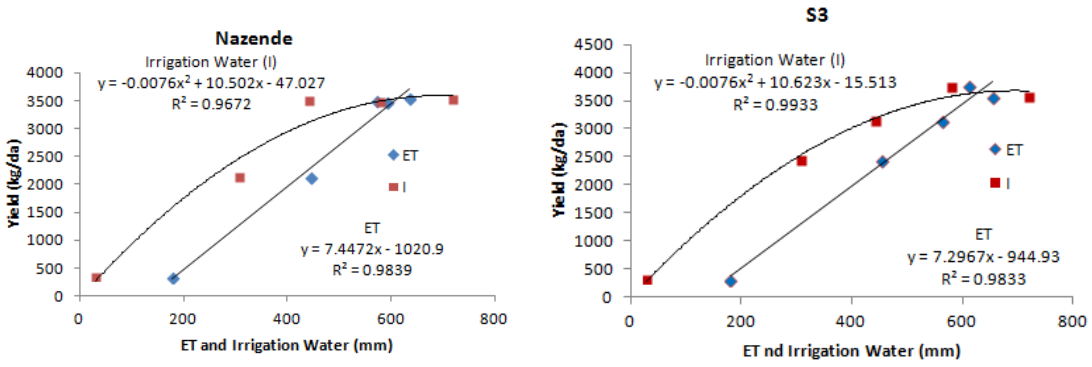

Figure 2. Relationships Between Irrigation Water, ET and Yield.

Linear relationship between ET and snap bean yield were indicated by several researches as Gençoğlan et al. (2006), Köksal et al. (2008), Sezen et al. (2008) and Saleh et al. (2018). Polynomial relationships between irrigation level and snap bean yield were also indicated by Bozkurt & Mansuroglu (2018).

Yield response factor (Ky) explains the complex relationship between production and water used by crop, where many chemical, physical and biological processes are included. The ky values are crop exclusive and vary over the growing season. (Steduto et al. 2012). The relative yield reduction and relative evaportranspiration values were given in Table 5 and Table 6 for Nazende and S3 respectively.

Table 5. The Relative Yield Reduction and Relative Evapotranspirasyon Values for Nazende

Treatment	ETm(mm)	ET (mm)	1-ETa/ETm	Ym(kg ha^{-1})	Ya(kg/ ha^{-1})	1-Ya/Ym
Kcp_1	635		0.00	35250		0.00
Kcp_2		592	0.07		34757	0.01
Kcp_3		573	0.10		34800	0.01
Kcp_4		445	0.30		21247	0.40
Kcp_5		177	0.72		3273	0.91

Table 6. The Relative Yield Reduction and Relative Evapotranspirasyon Values for S3

Treatments	ETm(mm)	ET (mm)	1-ETa/ETm	Ym(kg ha^{-1})	Ya(kg ha^{-1})	1-Ya/Ym
Kcp_1	655		0.00	38344*	35807	0.00
Kcp_2		612	0.07	37620		0.02
Kcp_3		563	0.14		31533	0.18
Kcp_4		455	0.31		24480	0.36
Kcp_5		181	0.72		3250	0.92

*The corrected maximum yield value calculated by using equation Ym: 7.2967ET-944.93 according to methodolgy given by Köksal et al. (2001).

The relationship between relative yield reduction and relative evapotranspiration deficit for snap bean were given in Figure 3.

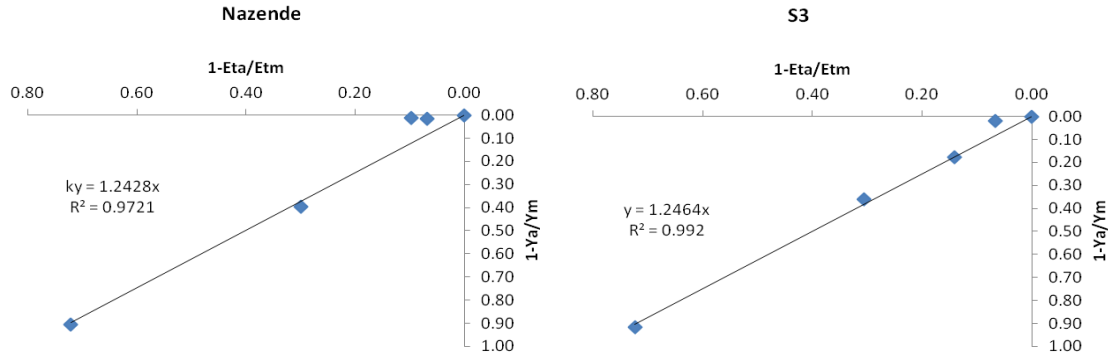

Figure 3. Yield Response Factors (ky) for Varieties.

The higher ky values than 1 means that crop is affected negatively water deficit and water reductions because of stress results higher yield reductions (Steduto et al., 2012) ky values calculated for both variety were similar and higher than 1. So it was concluded that both variety response to water stress negatively and very sensitive to water deficit. Gençoğlan et al. (2006), Sezen et al. (2005) and Doorenbos & Kassam (1979) reported ky values higher than 1.

Increasing water to 720 mm from 444 mm didn't affect the yield statistically for both varieties. Water use efficiency (WUE) and irrigation water use efficiency (IWUE) are summarized for both varieties in Table 7. When irrigated treatments considered, the highest WUE and IWUE values were obtained as 6.07 and 7.84 kg m^{-3} for Nazende variety in Kcp3 treatment. For S3 variety highest WUE value was obtained in Kcp2 treatment as 6.15 and highest IWUE value was obtained as 7.95 in Kcp4 treatment for S3 respectively. When IWUE values of the treatments where the highest yield obtained for Nazende (kcp1) and S3 (Kcp2) compared, It was found that Nazende's values (4.90 and 5.98 kg m^{-3}) were lower than S3's values (4.97 and 6.48 kg m^{-3}) that means S3 produces more yield than Nazende for per m^3 of irrigation water amount. The present results are similar with the results of several studies as El-Noemani et al. (2010), Saleh et al. (2018) who stated pod yield differed among varieties.

Table 7. Water Use Efficiency (WUE) and Irrigation Water Use Efficiency (IWUE) Data of Irrigation Treatments and Varieties (kg m^{-3})

Treatments	WUE		IWUE	
	Nazende	S3	Nazende	S3
Kcp_1	5.55	5.47	4.90	4.97
Kcp_2	5.87	6.15	5.98	6.48
Kcp_3	6.07	5.60	7.84	7.10
Kcp_4	4.77	5.38	6.90	7.95
Reinfed	1.85	1.80	10.91	10.83

The yield parameters of snap bean varieties obtained the study are given in Table 8. For both varieties, it was found that significant differences between irrigation treatments in terms of pod length, pod width, pod thickness and seed per pod. The physical properties of snap bean varieties are affected positively by increasing in irrigation water amount.

Table 8. Physical Properties of Snap Bean and Significance Groups

Plant-Pan Coefficient	Pod Length (cm)			Pod Width (mm)			Pod Thickness (mm)			Seed Per Pod		
	Nazende**	S3**	Mean**	Nazende**	S3**	Mean**	Nazende	S3	Mean**	Nazende*	S3*	Mean
1.25	12.6	15.1	13.9a	14.4	11.9	13.1a	6.6	7.1	6.9c	5.6	3.8	4.7a
1.00	11.9	14.7	13.3a	13.8	12.8	13.3a	8.0	8.5	8.3a	4.8	4.1	4.4a
0.75	11.0	12.3	11.6c	14.4	11.3	12.9a	7.7	7.2	7.4ab	3.9	2.7	3.3b
0.50	11.4	14.6	13.0ab	14.2	12.0	13.1a	7.5	7.7	7.6ab	4.6	4.1	4.4a
0.00	11.3	12.5	11.9bc	12.5	10.0	11.3b	6.7	6.6	6.6c	4.6	3.2	3.9b
Mean	11.6a	13.8b		13.8a	11.6b		7.3	7.4		4.7a	3.6b	

**p<0.01, *p<0.05,

Quality parameters measured in this study showed that significant differences between varieties in terms of pod length, pod width and seed per pod but not for pod thickness. It was found that the pods of the Nazende variety is longer in length, wider in width and have more seed per pod than S3 variety.

Statistical analyses of snap bean pod color parameters (L, a, b) indicated that irrigation water level has no effect on L, a and b value which is in agreement with Sezen et al. (2008) for a and b values but not for L values (Table 9). Ferreira et al. (1993) have stated that color b values were affected by the irrigation.

Table 9. Pod Color Values and Significance Groups

Plant-Pan Coefficient	L			a			b		
	Nazende	S3	Mean	Nazende**	S3**	Mean	Nazende**	S3**	Mean
1.25	56.9	58.6	57.7	-16.6	-14.8	-15.7	30.4	27.8	29.1
1.00	53.9	57.8	55.8	-16.1	-14.5	-15.3	31.2	28.5	29.9
0.75	59.1	59.3	59.2	-17.0	-14.9	-16.0	31.6	27.6	29.6
0.50	61.1	62.3	61.7	-17.4	-14.6	-16.0	32.4	28.3	30.4
0.00	56.3	53.4	54.9	-16.8	-13.7	-15.3	30.8	27.3	29.1
Mean	57.46	58.28		-16.8a	-14.5b		31.3a	27.9b	

**p<0.01, *p<0.05

"a" values ranged between 16.1 and 17.4 for Nazende and 13.7 to 14.9 for S3 variety. Nazende has lower "a" values than S3. "b" values ranged between 30.8 and 32.4 for Nazende and 29.1 and 30.4 for S3. According to color values S3 were greener and yellower than Nazende. Martınez et al. (1995) have stated that different color values obtained between the varieties included in their studies.

Conclusions

In this research, the response of two green bean varieties to different irrigation water levels under drip irrigation has been investigated. It was determined that snap bean seasonal evapotranspiration was ranged between 177 mm and 655 mm. It wasn't found significant difference between two snap bean varieties in terms of yield. So it can be concluded that S3 has a high marketability potential in Turkey market.

It was observed that there was significant relation between irrigation treatments and yield. For both varieties the irrigation treatments of which pan coefficients were 1.25, 1.00 and 0.75 are included in same statistical group. The irrigation water applied to the treatment where plant pan coefficient is 1.25 was 38% higher than the treatment where plant pan coefficient is 0.75. For Nazende snap bean variety, maximum yield was obtained from the treatment in which highest irrigation water applied. But for S3 variety the maximum yield was obtained from the treatment where pan coefficient is 1.00. It was concluded that maximum irrigation water doesn't mean the maximum yields for several varieties.

When the yields and irrigation water involved in same Duncan's grup interms of yield considered together, it can be seen that 62% and 31% more water were applied to kcp1 and kcp2 treatments than kcp3 treatments respectively. However the yield increase in kcp1 and kcp2 treatment is not more than 1.5% and 19% for Nazende and S3 respectively when compared the yields of kcp3 treatment. So that kcp3 irrigation treatment which produce highest IWUE values (7.84 and 7.10 kg m^{-3}) between treatments involved in same Duncan's group interms of yield can be recommended for both varieties in Konya region.

When IWUE values of the treatments where the highest yield obtained for Nazende (kcp1) and S3 (Kcp2) compared, it was observed that S3 produced more yield than Nazende for per m3 of irrigation water amount. The ky values of the varieties was found around 1.24 that means both variety were affected by water stress negatively with same way.

In addition, when the pod color values were considered, it was concluded that the irrigation water amount has no effect on pod color values. When the changes in snap bean pod color observed during production, it is suggested to investigate other factors except water stress for the reasons of change in pod color.

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