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Research Article

Effects of Different Irrigation Levels on Selected Crop Parameters of Sesame (*Sesamum indicum* L.) Under Semi-Arid Highland Conditions in Turkey

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Abstract

A trial was carried out in the fields of Siirt University (Turkey) to determine the effects of different irrigation levels on selected crop parameters of three sesame genotypes. Applications of different water consumption levels (WCL) (35%, 70% and 100% water levels; S1, S2 and S3 respectively) were in the main plots and varieties were in sub-plots. Trials were established in three replications according to the divided parcels experimental design in the random blocks. Two sesame cultivars (Arslanbey and Hatipoğlu) and one sesame genotype (Hat-2) were used. Plant height were higher for Hatipoğlu and Arslanbey varieties (111,1 cm and 107,4 cm, respectively). In relation with water consumption levels, plant heights were higher at S3 treatment for both years and S2 treatment for 2017. First branch height were higher for Arslanbey variety and Hat-2 genotype (7,37 cm and 6,36 cm, respectively). In relation with water consumption levels, plant heights were higher at S3 treatment for both years and S2 treatment for 2016.
Branch number were higher for Hatipoglu variety (8,52 pieces) and lower for Arslanbey variety (3,48 pieces) and Hat-2 genotype (3,74 pieces). In relation with water consumption levels, branch number were higher at S1 and S2 treatments for both years. Hatipoglu variety in 2017 year produced highest (9,47 pieces), whereas Arslanbey variety in 2016 produced lowest (2,79 pieces) branch number. Number of capsules per plant values were higher for Hat-2 genotype (160,8 pieces) and Arslanbey varieties (151,3 pieces). Number of capsules per plant was 135,5 pieces for Hatipoğlu variety. Number of seeds per capsules values were higher for Hat-2 genotype (85,42 pieces) and lowest for Hatipoğlu variety (79,26 pieces). None of the application was effective on 1000 seed weight values.

Keywords: Sesame, *Sesamum indicum* L., irrigation level, arid climate

Türkiye'de Yarı Kurak İklim Koşullarında Farklı Sulama Düzeylerinin Seçilmiş Susam (Sesamum indicum L.) Ürün Parametrelerine Etkisi

Öz

Farklı sulama seviyelerinin üç susam genotipinin seçilen ürün parametreleri üzerindeki etkilerini belirlemek için Siirt Üniversitesi (Türkiye) deneme tarlalarında yapılmıştır. Farklı su tüketim seviyeleri (WCL) uygulamaları (sırasıyla %35, %70 ve %100 su seviyeleri; S1, S2 ve S3) ana parsellerde, çeşitler ise alt parsellerde yer almıştır. Denemeler rastgele bloklarda bölünmüş parseller deneme desenine göre üç tekerrürlü olarak kurulmuştur. İki susam çeşidi (Arslanbey ve Hatipoğlu) ve bir susam genotipi (Hat-2) kullanılmıştır. Hatipoğlu ve Arslanbey çeşitlerinde bitki boyu daha yüksek bulunmuştur (sırasıyla 111,1 cm ve 107,4 cm). Su tüketim seviyeleri ile ilgili olarak, bitki boyları her iki yılda da S3 su tüketim seviyesi ve 2017 için S2 su tüketim seviyesinden daha yüksektir. Ilk dal yüksekliği Arslanbey çeşidi ve Hat-2 genotipinde (sırasıyla 7,37 cm ve 6,36 cm) daha yüksekti. Su tüketim seviyeleri ile ilgili olarak, bitki boyları her iki yılda da S3 arıtımında ve 2016 yılı için S2 arıtımında daha yüksekti.
Dal sayısı Hatipoğlu çeşidinde (8,52 adet), Arslanbey çeşidinde (3,48 adet) ve Hat-2 genotipinde (3,74 adet) daha düşüktür. Su tüketim düzeylerine bağlı olarak her iki yılda da S1 ve S2 uygulamalarında dallanma sayısı daha yüksek çıkmıştır. 2017 yılında Hatipoğlu çeşidi en yüksek (9,47 adet), Arslanbey çeşidi ise 2016 yılında en düşük (2,79 adet) dallanma sayısına sahiptir. Bitki başına kapsül sayısı değerleri Hat-2 genotipi (160,8 adet) ve Arslanbey çeşitleri (151,3 adet) için daha yüksek bulunmuştur. Hatipoğlu çeşidinde bitki başına kapsül sayısı 135,5 adettir. Kapsüldeki tohum sayısı değerleri Hat-2 genotipinde (85,42 adet) daha yüksek, Hatipoğlu çeşidinde (79,26 adet) en düşük olmuştur. Uygulamaların hiçbiri 1000 tohum ağırlığı değerlerinde etkili olmamıştır.

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Anahtar Kelimeler: Susam, *Sesamum indicum* L., sulama seviyesi, kurak iklim

1. Introduction

Sesame (Sesamum indicum L.) is an erect, annual plant of Pedaliaceae family (Sharma et al., 2021) with indeterminate, generally tall and branched growth habit (Tripathy et al., 2019). Its seed oil is a part of the daily edible oil for half of the global population (Wei et al., 2014). Sesame oil presence increases in Western diet (Nachshon et al., 2019). Sesame has high oil content and quality. Unsaturated fatty acids, proteins and antioxidants in its seeds are attractive and increasing consumption of sesame seed products (Zhang et al., 2019).

In wide agro ecological zones in the world, many different varieties of sesame exist (Nagendra Prasad et al., 2012). Low yield is a major constraint for its cultivation (Jayaramachandran et al., 2020). Inherently low genetic yield potential and susceptibility to biotic and abiotic stresses are the reasons for low productivity of sesame. Development of stress tolerant high yielding varieties is needed (Jyothi et al., 2011). The gap between the potential and realized yields in sesame is very high due to capsule shattering and sensitivity to a biotic and abiotic stresses (Tripathy et al., 2019). Plant architecture modification is required to increase harvest index. Selection for medium plant height (approximately one meter) with high capsule density starting from 15-20 cm above the soil level is needed (Tripathy et al., 2019).

Sesame production is common in marginal and semi-marginal lands (Pandey et al., 2017). Its cultivation is between latitudes 30 S to 43 N (Langham et al., 2021). Sesame crop is widely grown in tropical and subtropical countries as a major oil and protein source (Wang et al., 2014). It is grown typically by smallholders mainly in developing countries. Inappropriate fertilizers usage is among the major constraints for its production (Zenawi & Mizan, 2019). Seed yield and quality siginificantly get affected from drought stress (You et al., 2019). Genotype and drought stress affect quality and quantity of extractable oil (Kadkhodaie et al., 2014).

This study was carried out to determine the effects of different irrigation levels on selected crop parameters of three sesame genotypes under semi-arid highland conditions in Turkey.

2. Material and Method

The trial was carried out in the field crops trial area of the Faculty of Agriculture of Siirt University in 2016 and 2017. Applications of different water consumption levels (35%, 70% and 100% water levels; S1, S2 and S3 respectively) were in the main plots where varieties were in sub-plots in the experiment, which was established with three replications according to the divided parcels experimental design in the random blocks. Two sesame cultivars (Arslanbey and Hatipoğlu) and one sesame genotype (Hat-2) were used. Row length was 6 m, interrow spacing was 70 cm, and intrarow spacing was 15 cm. Soil analysis was conducted before trial and the results are given in Table 1 below. The data were subjected to split plots experimental design in random blocks with jmp statistics program.

Table 1. Some physical and chemical properties of the experimental field soil

Soil Properties	Soil layer (cm)		
	0-30	30-60	60-90
Texture	Clay	Clay	Clay
Clay (%)	57,12	55,12	53,12
Silt (%)	22,0	16,0	14,0
Sand (%)	20,88	28,88	24,88
Field capacity (FC)	33,52	36,04	35,38
Wilting point (Pw)	24,44	26,08	25,57
Bulk density (g cm^{-3})	1,42	1,39	1,41
pH (1:2.5 s/w)	7,50	7,66	7,91
Electrical conductivity (dS m^{-1})	1,55	1,77	1,75

The soil was in clay texture with low electrical conductivity and moderate level of organic matter. Calcium carbonate content level of experimental soil was high. Plant available phosphorus concentration was low and potassium content was high. Mean field capacity (FC) was 433 mm in average depth (0-90 cm), wilting point (WP) was 312 mm and plant available water retention capacity of soils was 121 mm. Average bulk density of soil samples was 1,40 gr cm-3.

Considering the soil analysis, diammonium phosphate and urea fertilizers were applied to each plot homogeneously, with calculation of 80 kg/ha of phosphorus and 40 kg/ha of nitrogen over the pure substance in accordance with Arslan and Gür, (2018). Under the second crop conditions, following the wheat harvest, sowings was carried out manually by hand in the first and second years on 26.06.2016 and 05.07.2017, respectively. Complete emergences was achieved approximately one week after plantings. After the plant emergence stage, intrarow plant populations were reduced to homogenous distances. Twice hoeing was conducted. Since no diseases, pests and weeds were observed as a result of hoeing, pesticide spraying was not applied. Long term climate data of the study area during sesame growing season and long term period are presented in Table 2

The study area is under continental climate which is characterized by cold and rainy/snowy winters, and hot and dry summers. Long term average temperature of the region in summer is 26 ºC in and 2,7 ºC in winter. The maximum and minimum relative humidity are 70,2% and 26,9% in in January and August, while the long-term annual average relative humidity is 50,4%. Long term annual precipitation is 669,2 mm, and monthly precipitation ranges from 103,6 mm to 1,3 mm.

A total of 10 irrigations were performed according to the targeted irrigation levels. The irrigation treatments were full irrigation (I100) where 100% of the consumed water is used (I100, control) and two limited irrigations subjects to 70% (I70) and 35% (I35) of the full irrigation. Electrical conductivity (EC), pH, and anion and cation concents of the irrigation water were determined by a method described by Tuzuner, 1990. Water analyses revealed that irrigation water quality class was C2S1 which describes high quality irrigation water with an EC of 0.34 dS m-1 and a pH of 7.21. Irrigation water was safe to use in irrigating the sesame plants.

Harvesting was carried out when the color of the seeds became darker. Before manual hand harvest, 0,5 m from both ends of parcels and each both side plant lines were cut out and thrown. Rest middle two rows were harvested. Harvest dates were 26.10.2016 and 01.11.2017 in first and second years, respectively.

Table 2. Climatic data for 2016 and 2017 years and log-term average (1962-2015)

		Mean Min Temp. (°C)	Mean Temp. (°C)	Mean Max Temp. (°C)	Mean Humidity (%)	Mean wind Speed (m s-1)	Mean daily Sunshine (h)	Total precipitation (mm)
Average of 1962 -2015	May	25.2	19.4	9.0	49.3	1.0	9.1	36.9
	June	27.2	26.0	17.8	34.9	1.1	11.6	11.5
	July	35.1	30.5	23.4	30.3	1.1	12.3	0.6
	August	34.5	30.3	27.0	29.5	1.0	11.4	2.7
	September	30.0	25.1	14.7	37.4	1.0	10.1	7.0
	October	24.5	17.9	12.7	42.0	1.0	7.2	50.9
2016	May	26.62	19.29	14.52	50.87	1.0	8.7	39.6
	June	26.09	28.16	20.0	35.50	1.1	11.5	10.6
	July	34.13	31.45	24.35	32.69	1.0	12.4	0.1
	August	33.92	31.19	24.23	32.95	1.0	11.3	0.4
	September	31.23	25.43	21.5	39.90	1.1	10.0	9.2
	October	24.3	16.8	11.5	42.3	1.1	7.0	55.1
2017	May	24.69	21.29	14.59	51.77	1.0	9.3	37.7
	June	28.19	28.41	20.25	34.40	1.1	12.0	9.3
	July	36.24	33.19	25.35	29.69	1.0	12.5	0.1
	August	35.92	32.45	24.73	29.95	1.0	11.5	0.0
	September	32.23	27.43	21.65	36.79	1.1	10.0	12.2
	October	21.1	19.7	12.0	44.2	1.0	7.3	69.20

3. Results and Discussion

3 Variety and “WCL x year interaction” were found significant for plant height. Plant height were higher for Hatipoğlu and Arslanbey varieties (111,1 cm and 107,4 cm, respectively). In relation with water consumption levels, plant heights were higher at S3 treatment for both years and S2 treatment for 2017 (Table 3). Variety and “WCL x year interaction” were found significant for first branch height. First branch height were higher for Arslanbey variety and Hat-2 genotype (7,37 cm and 6,36 cm, respectively). In relation with water consumption levels, plant heights were higher at S3 treatment for both years and S2 treatment for 2016 (Table 3).Variety, “WCL x year interaction” and “variety x WCL interaction” were found significant for branch number. Branch number were higher for Hatipoglu variety (8,52 pieces) and lower for Arslanbey variety (3,48 pieces) and Hat-2 genotype (3,74 pieces). In relation with water consumption levels, branch number were higher at S1 and S2 treatments for both years. Hatipoglu variety in 2017 year produced highest (9,47 pieces), whereas Arslanbey variety in 2016 produced lowest (2,79 pieces) branch number (Table 4). Variety were found significant for number of capsules per plant in which this value were higher for Hat-2 genotype (160,8 pieces) and Arslanbey varieties (151,3 pieces). Number of capsules per plant was 135,5 pieces for Hatipoğlu variety (Table 4).

Table 3. Plant height and first branch height data obtained in the study

	Year	Plant height (cm) S1	S2	S3	Mean	First branch height (cm) S1	S2	S3	Mean
		Water consumption level				Water consumption level			
Arslanbey	2016	102,2	104,3	108,5	104,9	8,13	10,33	8,20	8,89
	2017	107,3	100,7	121,6	109,9	4,80	5,93	6,80	5,84
Mean		104,8	102,5	115,0	**107,4 ab**	6,47	8,13	7,50	7,37 a
Hatipoğlu	2016	111,1	109,2	114,8	111,7	3,30	3,70	4,37	3,79
	2017	105,3	113,5	112,5	110,5	3,20	2,53	2,60	2,78
Mean		108,2	111,4	113,7	**111,1 a**	3,25	3,12	3,48	3,28 b
Hat-2	2016	98,7	104,9	105,1	102,9	6,53	7,47	7,60	7,20
	2017	97,9	107,1	106,3	103,8	5,93	3,73	6,87	5,51
Mean		98,3	105,9	105,7	**103,3 b**	6,23	5,60	7,23	6,36 a
Mean of 2016		**103,9 b**	**106,1 b**	**109,5 ab**	106,5	5,99b	7,17a	6,72a	**6,63 a**
Mean of 2017		**103,5 b**	**107,1 ab**	**113,5 a**	108,0	4,64b	4,07b	5,42a	**4,71 b**
General Mean		103,7	106,6	111,5	107,3	5,32	5,32	5,62	6,07
CV			6,64				22,01		
LSD variety			4,9*				1,47**		
LSD WCL x year			6,93*				1,2**		
LSD variety x WCL			ns						

* WCL:Water consumption level; ns:non-significant

Table 4. Branch number and number of capsules per plant data obtained in the study

Variety	Year	Branch number S1	S2	S3	Mean	Number of capsules per plant S1	S2	S3	Mean
		Water consumption level				Water consumption level			
Arslanbey	2016	3,83	2,20	2,33	2,79 d	165,6	117,8	148,8	144,1
	2017	4,33	4,47	3,73	4,18 c	195,9	145,2	134,1	158,4
Mean		4,08	3,33	3,03	**3,48 b**	180,8	131,5	141,5	**151,3 ab**
Hatipoğlu	2016	8,23	7,27	7,20	7,57 b	125,9	121,3	146,2	131,1
	2017	8,93	9,67	9,80	9,47 a	116,7	157,0	146,1	139,9
Mean		8,58	8,47	8,50	**8,52 a**	121,3	139,1	146,1	**135,5 b**
Hat-2	2016	4,02	3,53	3,57	3,71 cd	158,0	167,6	184,3	170,0
	2017	4,00	4,33	3,00	3,78 c	175,2	134,7	145,1	151,7
Mean		4,01	3,93	3,28	**3,74 b**	166,6	151,1	164,7	**160,8 a**
Mean of 2016		5,36	4,33	4,37	4,69 b	149,8	135,6	159,8	148,4
Mean of 2017		5,76a	6,16a	5,51b	5,81 a	162,6	145,6	141,8	150,0
General Mean		5,56a	5,24a	4,94b	5,25	156,2	140,6	150,8	149,2
CV			19,03						22,4
LSD variety			0,68**						22,9*
LSD WCL x year			0,56**						
LSD variety x WCL			0,97*						

* WCL:Water consumption level; ns:non-significant

Table 5. Number of seeds per capsule and 1000 seed weight data obtained in the study

Variety	Year	Number of seeds per capsule – Water consumption level S1	S2	S3	Mean	1000 seed weight – Water consumption level S1	S2	S3	Mean
Arslanbey	2016	81,07	82,13	83,87	82,36	3,75	3,83	4,00	3,86
	2017	82,00	80,00	84,67	82,22	3,83	3,83	4,08	3,92
Mean		81,53	81,07	84,27	**82,29 b**	3,79	3,83	4,04	3,89
Hatipoğlu	2016	82,00	76,53	76,67	78,40	3,75	3,75	4,00	3,83
	2017	81,00	78,67	80,67	80,11	3,92	3,75	4,08	3,92
Mean		81,50	77,60	78,67	**79,26 c**	3,83	3,75	4,04	3,88
Hat-2	2016	87,60	88,40	84,53	86,84	4,00	4,33	3,83	4,06
	2017	82,67	84,67	84,67	84,00	4,08	4,58	3,92	4,19
Mean		85,13	86,53	84,60	**85,42 a**	4,04	4,46	3,88	4,13
Mean of 2016		83,56	82,36	81,69	82,53	3,83	3,97	3,94	3,92
Mean of 2017		81,89	81,11	83,33	82,11	3,94	4,06	4,03	4,01
General Mean		82,72	81,73	82,51	82,32	3,89	4,01	3,99	3,96
CV					4,15				9,65
LSD variety					2,35**				
LSD WCL x year									
LSD variety x WCL									

* WCL:Water consumption level; ns:non-significant

Variety were found significant for number of seeds per capsules in which this value were higher for Hat-2 genotype (85,42 pieces) and lowest for Hatipoğlu variety (79,26 pieces) (Table 5) None of the application was effective on 1000 seed weight values (Table 5).

4. Conclusions and Recommendations

Increased irrigation level increased plant height and reduced branch number. Irrigation was not effective on first branch height, number of capsules per plant and 1000 seed weight values.

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