Journal of Plant Production

Journal homepage & Available online at: www.jpp.journals.ekb.eg

Evaluation of Some Soybean Genotypes under Irrigation Water Shortage Conditions

Azza F. El-Sayed[1*]; T. S. Mohamed[1] and M. I. Badawi[2]

[1]Food Legume research department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt.
[2]Water Requirements and Field Irrigation Research Department, Soils, Water and Environment Research Institute,Agricultural ResearchCenter, Giza, Egypt

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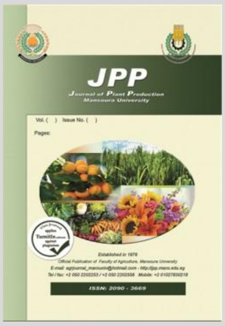

ABSTRACT

The current investigation was carried out at Gemmeiza Agricultural Research Station, Agricultural Research Center, Egypt, during 2021 and 2022 summer seasons to investigate the response of five soybean genotypes (DR 101, H_4L_4, PI416-937, Giza 35 and Giza 111) to three irrigation intervals (14, 21 and 28 days).The results showed that Giza 111 cultivar was superior over other genotypes at the different irrigation intervals in yield components traits (number of pods and seeds per plant, seed weight plant^{-1}, seed index, seed yield fed^{-1} and Land use efficiency (L.U.E). Giza 111 irrigated every 14 days was the best treatment; producing the highest seed yield fed^{-1}.Pods, seeds, seed weight plant^{-1}, seed index and Land use efficiency (L.U.E) were significantly higher with the same combination followed by those irrigated every 21 and 28 days**.** Irrigation every 21and 28days caused reductions in seed yield and its components as compared to irrigation every 14 days. Reduction in seed yield faddan^{-1} due to prolonging irrigation intervals from 14 (recommended) to 21 and 28 days were 2 and 6 % in Giza 111 cultivar, 9 and 12 % in Giza 35, 8 and 20 % in DR 101, 11 and 17% in H_4L_4 and 24 and 28% in PI 416-937. This means that in case of water shortage Giza 111cultivar could be successfully grown under irrigation intervals up to 28 days, recording the highest value of water use efficiency as well as water productivity.

Keywords: Soybean, irrigation intervals, seed index, water use efficiency, water productivity.

INTRODUCTION

Soybean (*Glycine max* L Merrill) is one of the most significant oil seed and protein crops in the world. Among all leguminous crops, its seeds have the highest protein content (40 %). (Sinclair *et al.* 2014),and about 20% of cholesterol-free oil so it is a good alternative to meat, poultry and sea food, and it contains significant amounts of most essential amino acids for the human body, and it also contains linoleic acid, which reduces the risk of heart disease (Sacks *et al.* 2006).Soybean seeds are used as a source of cooking oil, and for many other purposes (Myaka *et al.* 2005). Nevertheless, the leaves of soybean plants can be used as hay, pasture, cover, and green manure. (Essa and Al-Ani 2001).In Egypt, the average area cropped to soybean from 2017 to 2021 was around 35439 faddan, with an average seed yield of 1.230 tonfad^{-1}, and total production approximately 43971 tons (Bulletin of Statistical Cost Production & Net Return (2021). The increase in soybean acreage as a summer crop to face the great demand is very difficult because of competition with other strategic crops such as cotton, corn and rice, especially under limited land and water resources. As a result, it's essential to boost soybean productivity per unit area and/or expand horizontally on recently reclaimed land. Soybean growing season in Egypt typically takes from 110 to 130 days and requires from 2500 to 3000 m^3 of water according to soil type and climatic conditions. Irrigation is one of the most important variables influencing soybean growth and production. Water shortage at Canal Tail-ends has a hurt the crops grown on both sides of the canal ends. The percentage of cultivated land affected by water shortage at canal ends reached about 20% (Walla and Elyamany 2018).

In Egypt, water has become a scarce resource in recent years. As a result, there has been a greater focus on finding technologies and conservation strategies for irrigation. So, it is essential to determine the ideal water requirements for different crops and design the ideal irrigation schedule. More focus was placed on protecting the water resources by reducing losses, using less water, and providing farmers with the optimal irrigation schedule. Soybean growth and yield are negatively affected by the exposure to soil moisture stress, particularly during pod development and seed filling (Kranz *et al.*, 1998). Hence, lowering plant water consumption by longer irrigation intervals will save irrigation water, along with maintaining a comparable economic output. (Gamalate *et al* 2013). Ibrahim and Kandil (2007), on soybean, found that irrigation intervals significantly affected growth and yield parameters in clay loam soil. Irrigation every 14 days recorded the tallest plants, the greatest plant dry weight and number of seeds plant^{-1}, and the highest seed yieldfed^{-1}, compared with irrigation every 7 and 21 days. At this point, one irrigation could boost grain output since pod filling is the most critical stage to water stress and water scarcity. (Jaimes, (2011) and, Chaf*et al.*, (2012) recorded the highest soybean yield (5125.6 kg ha^{-1}) at irrigation every 12 days. The effect of irrigation every 2or 3 weeks on growth and yield of soybean was studied by Hussein *et al.* (2019) who observed that prolonging irrigation intervals significantly decreased plant height, branches plant^{-1}, leaf area index (LAI), pods plant^{-1} and dry weight plant^{-1}. Days to flowering and maturity, plant height, branches and pods plant^{-1}, seedspod^{-1}, seed index, seed yield feddan^{-1} and water consumptive use were

[*] Corresponding author.
E-mail address: azza.fathy@yahoo.com

DOI: 10.21608/jpp.2025.351519.1430

significantly increased with the increase in available soil moisture (ASM%). The maximum values of water use efficiency (WUE) were recorded from plots irrigated at 35% of available soil moisture followed by those irrigated at 50% (El-Karamity, 1998).The present study aimed at improving productivity of soybean in case of irrigation water shortage occurred during the growing season for one reason or another.

MATERIALS AND METHODS

Site Description:

A field experiment was conducted during 2021-2022 summer growing seasons at El-Gemmeiza Agric.; Res.Station Farm, El-Gharbia Governorate, ARC, located between longitude 30° 57′ 8″ E, latitude 30° 58′ 56″ N-, and m altitude above mean sea level), Al- Garbia Governorate, and Egypt. The soil physical, chemical properties and soil-moisture constants at the experimental site, determined according to Page *et al.* (1982) and Klute (1986), are listed in Tables 1 and 2.

Table 1. Some soil physical and chemical properties at the experimental site in 2021 and 2022 seasons.

Soil properties	Seasons	
Soil particles (%)	1^{ST}	2^{nd}
Coarse sand	2.88	3.10
Fine sand	13.85	14.16
Silt	31.37	33.46
Clay	51.90	50.72
Texture	Clay	Clay
Chemical analysis		
Available N (mg kg^{-1})	40.12	42.58
Available P (mg kg^{-1})	19.64	21.28
Available K (mg kg^{-1})	271.22	285.74
pH (1:2.5)	7.69	8.13
E.C. (ds m^{-1})	1.17	1.21
O.M. (%)	1.65	1.78
CaCO3 (%)	2.48	2.67

Table 2. Some soil water constants and bulk density at the experimental site.

Soil depth (cm)	Bulk density (gcm^{-3})	Field capacity(wt./wt.)		Wilting Point(wt./wt.)		Available water,	
		%	Mm	%	mm	%	mm
0 – 15	1.10	45.6	75.24	24.3	40.10	21.3	35.15
15 – 30	1.20	42.3	76.14	22.1	39.78	20.2	36.36
30 – 45	1.31	39.5	77.62	21.0	41.27	18.5	36.35
45 – 60	1.38	36.9	76.38	18.6	38.50	18.3	37.88
Mean	1.18	41.1	……..	21.5	…….	19.6	∑ 145.7

Experimental design and tested treatments:

The Randomized Complete Block design (RCBD) in split plot arrangement with three replications was used to implement the field experiment. Irrigation intervals represented the main plots and sub-plot contained soybean genotypes as follows:

Irrigation interval treatments (main plots):

I_1: 14 days
I_2: 21 days
I_3: 28 days

Genotypes **(sub-plots):**

G_1: DR 101
G_2: H_4L_4
G_3:PI416-937
G_4: Giza 35
G_5: Giza 111

Soybean genotypes were obtained from Food Legume Research Department, Agricultural Research Center, and Giza, Egypt. Maturity group, growth habit and pedigree of those materials are presented in Table (3). Each sub-plot consisted of 5 ridges 3.5 m long and 60 cm apart occupying an area of 10.5 m^2. The preceding crop was potato in both seasons. The surface system, irrigation interval is used based.

Table 3. Maturity group, growth habit and pedigree of soybean genotypes

Genotype	Maturity group	Growth habit	Pedigree
DR 101	IV	indeterminate	Selection from Elgin, Drought Resistant, USA
H_4L_4	V	determinate	DR 101 x Lamar
PI416-937	V	determinate	Drought Resistantgenotype, USA
Giza 35	III	Indeterminate	Crawford × Celest
Giza 111	IV	Indeterminate	Crawford × Celest

Cultural practices

The experimental field was fertilized with phosphorus at rate of 30 kg P_2O_5fadden^{-1} (calcium superphosphate 15.5% P_2O_5). A starter dose of 15 kg N feddan^{-1} in the form of urea (46.5% N) was added at sowing. Seed was inoculated with the specific *Brady Rhizobium japonicum*, 15 minutes before sowing. The commonly known improved Afir method of sowing was used. Sowing took place on 25th of May in hills 20 cm apart on both sides of the ridge in both seasons. Irrigation water was added to all plots immediately after seeding. Thinning was done two weeks after sowing at 2 seedlings hill^{-1} to attain the desired population of 140,000 plants fed^{-1}. Plots were kept weed-free throughout the growing seasons. The normal agricultural practices of growing soybean were followed. Number of days to 50 % flowering and to 90% maturity were recorded. At harvest.

Measurements of crop yield

1- Plant height (cm): It was measured from soil surface up to the top of leaf tip of the plant from ten plants randomly chosen from the central three ridges before each cut.
2- Number of branches, pods and seeds per plant and seed weight plant^{-1}.
3- Seed yield per plot, which transformed to seed yield per feddan (1 feddan = 4200 m^2).
4- Seed index (100-seed weight) was recorded for each plot.
5- Land use efficiency (L.U.E) kg seeds day^{-1} was estimated according to the following equation: LUE = Seed yield fed^{-1}/Number of days from sowing to maturity

Irrigation-water measurements and crop-water relations

Water consumptive use (WCU)

Crop water use was estimated by soil samples were taken before and 48 hours after each irrigation, as well as at harvest time in 15 cm increment to 60 cm depth of the soil profile. The crop water consumptive use between two successive irrigations was calculated according to the equation given according to Majumdar (2002) and calculated as follows:

$$WCU = \sum_{i=1}^{i=4} (Q2 - Q1) x D x Bd/100$$

Where: **WCU= seasonal water consumptive use (cm),**
Q_2= soil moisture content after irrigation (on mass basis, %),
Q_1= soil moisture content before irrigation (on mass basis, %),
Bd= soil bulk density (gcm^{-3}),
D= depth of soil layer (15cm each), and
i= number of soil layer

Applied irrigation water (AIW):

Submerged flow orifice with fixed dimension was used to measure the amount of water applied, according to (Michael, 1978) as:

$$Q = CA\sqrt{2gh}$$

Where: Q =water discharged through the orifice, $cm^3 sec^{-1}$.
C =coefficient of discharge ranged from 0.6 up to 0.8.
A =cross-sectional area of the orifice, cm^2.
g =acceleration of gravity, 981 $cm sec^{-2}$.
h =pressure head causing discharge through the orifice, cm.

Water use efficiency (WUE)

Water use efficiency (WUE) is used to describe the relationship between production and the amount of water used. Water use efficiency was calculated according to Stanhill (1986) as follows:

$$WUE = seed\ yield\ (kg\ fed-1) \Big/ Seasonal\ ET\ (m3\ water\ consumed)\ fed.-1$$

Where:WUE = kg seeds m^{-3} water consumed.
Y= Seed yield (kg fed^{1}).
CU= Seasonal water consumptive use (m^3 fed^{-1}).

Water Productivity (WP):

Water productivity is an efficient term calculated as a ratio of product output over water input. The output could be biological goods such as crop grain, fodder….etc. So, water productivity, in the present study, is expressed as kilograms of soybean seed obtained per unit of applied irrigation water. The water productivity value was calculated in kg of soybean seed yield per m^3 of applied water according to the following equation FAO (2003):

WP (kg m^{-3}) =
Seed yield (kg fed^{-1}) / Seasonal applied water ($m^3 fed^{-1}$), FAO (2003).

Statistical analysis

Data were statistically analyzed according to Steel and Torrie 1980), and combined analysis was performed according to Gomes and Gomes (1984) after confirming homogeneity of error across seasons by Levene`s (1960) test. Means of treatments were compared by least significant difference test (LSD) at 0.05 level of probability significance.

RESULTS AND DISCUSSION

Differences due to irrigation intervals were significant for all traits, except 50 % flowering in both seasons, branches $plant^{-1}$ and seed index in the first season and seed yieldplant^{-1} in the second season. Genotypes differed significantly in all traits, except seed index in the first season as shown in (Tables 4, 5 and 6).

Data combined analysis of the two seasons(Table 4) indicated that Giza 35 cultivar was the earliest in flowering (36.7 days) and maturity (109.6 days). However, PI416-937 genotype was the latest recording 47.8 days and 147.9 days, respectively (Table 4). Prolonging irrigation intervals from 14 to 28days reduced days to 50% flowering and 90 % maturity. The earliest plants in flowering and maturity were recorded at irrigation every28 days (42.6 and 130.2), while the latest ones were observed at irrigation every 14 days (44.04 and 134.07), respectively. The interaction between genotypes and irrigation intervals showed that Giza 35cultivar irrigated every 28 days gave the earliest plants in flowering and maturity (36.3 and 108.3), but PI416-937 genotype irrigated every 14 days gave the latest plants (49.2 and 150.3).

Plant height and number of branches $plant^{-1}$ are important characteristics because they reflect plant vigor that led to high yield. This would be helpful in selecting parents for use in crossing programs (Eisa *et al.* 1998). With regard to these characters in Table (4), we can recognize that Dr 101 genotype had the shortest plants (106.9 cm) with the highest number of branches $plant^{-1}$ (4.0), while Giza 111 cultivar recorded the tallest plants (144.7 cm) with the fewest branches $plant^{-1}$ (2.6). The interaction showed that genotype Dr 101 irrigated every 28 days was the shortest (104.2 cm.) while the tallest plants were recorded at Giza 111cultivar irrigated every 14 days. For no. of branches $plant^{-1}$, Dr 101 and PI416937 genotypes irrigated every 14 days had the highest number of branchesplant^{-1} (4.1). However Giza 111 plants irrigated every 28 days had the lowest number (2.6).

These results were similar to those reported by Mohamed and Faiza (2005) who evaluated some soybean genotypes grown on new reclaimed lands at East Owinat. They found that plants of Giza 111, Giza 21, Giza 22, L 12,H32 and L 20 genotypes were significantly taller than the other genotypes. The largest number of branches $plants^{-1}$ was recorded in DR 101 and Toano genotypes. Irrigation every 14 days increased plant height and number of branches $plant^{-1}$ as compared to irrigation every 28 days. These increases were 5.92% and 18.15%, respectively.

These results were similar to those of Hussein *et al.,* 2019, who reported that providing the soil with water abundance enhanced soybean plant height and no. of branches plant ^{1}.Giza 111 cultivar recorded the highest mean values in the combined between the two seasons for yield component traits (pods, seeds, seed weight $plant^{-1}$, seed index, seed yield fed^{-1} and Land use efficiency (Tables 4 and 5).

Many researchers obtained similar results as Mohamed and Faiza (2005), Abd El-Hafez and Abo El-Soud (2007), Mohamed (2008), Abd El-Mohsen *et al.* (2015),Safina et al (2018), Khattab*et al.* (2019), El-karamity*et al.* (2023) and Eman*et al.* (2024).

On the other hand, PI 416-937 recorded the lowest values for these traits. The interaction in Tables 4 and 5 indicated that Giza 111 cultivar irrigated every 14 days was superior to other combinations in pods, seeds, seed weight $plant^{-1}$, seed index and seed yield fed^{-1}(120.74, 270.21, 41.425, 18.745 and 1.573,respectively), followed by Giza 35 cultivar irrigated every 14 days recording 94.50, 219.18, 34.705, 15.970 and 1.344, respectively.

Concerning irrigation intervals effect, the greatest number of pods, seeds, seed weight $plant^{-1}$, seed index, seed yield fed^{-1} and the best land use efficiency (L.U.E) were recorded from irrigation interval of 14 days compared to those irrigated every 21 and 28 days in both seasons (Tables 4 and 5).Reduction in seed yield faddan^{-1}due to prolonging irrigation intervals from 14 to 21 and 28 days were 2 and 6 % in Giza 111 cultivar, 9 and 12 % in Giza 35, 8 and 20 % in DR 101, 11 and 17% in H_4L_4 and 24 and 28% in PI 416-937, respectively.

This means that in case of irrigation water shortage, Giza 111 or Giza 35 cultivars can be grown under irrigation every 21 or 28 days with no harmful effect on productivity. Similar results were recorded by Khattab, *et al.* (2019), Ali and Abdel Aal (2021) and El-Karamity*et al.* (2023), they stated that shortage of water depressed translocation of metabolites from source to sink which is reflected on cell division and elongation. Plants subjected to water deficit via prolonging irrigation intervals gave lighter 100-seed weight. This is true since translocation of metabolites from source to different organs of soybean plants pod and seed formation stages was depressed with exposing plants to water deficit.

Table 4. Means of days to 50% flowering and to 90% maturity, plant height and branches plant-1of studied soybean genotypes as affected by three irrigation intervals and their interactions in both seasons and combined.

Irrigation interval (days)	Genotype	50% flowering 1^{ST}	50% flowering 2^{nd}	50% flowering Com.	90% maturity 1^{ST}	90% maturity 2^{nd}	90% maturity Com.	Plant height (cm) 1^{ST}	Plant height (cm) 2^{nd}	Plant height (cm) Com.	No. of branches plant^{-1} 1^{ST}	No. of branches plant^{-1} 2^{nd}	No. of branches plant^{-1} Com.
Irrigation interval (days)													
14		42.5	45.6	44.0	133.0	135.1	134.1	129.0	127.7	128.3	3.9	3.8	3.8
21		41.7	45.0	43.4	131.9	133.8	132.8	125.3	124.2	124.8	3.6	3.6	3.6
28		41.2	43.9	42.6	128.5	131.9	130.2	121.7	120.7	121.2	3.3	3.2	3.2
L.S.D 0.05		N.S	N.S	0.86	2.80	1.55	1.64	2.62	1.34	1.47	N.S	0.34	N.S
Genotype													
DR 101		42.4	45.6	44.0	135.4	142.3	138.9	108.9	105.0	106.9	4.1	4.0	4.0
H_4		43.4	46.9	45.2	137.1	140.9	139.0	113.9	116.1	115.0	3.3	3.2	3.3
PI416-937		45.3	50.3	47.8	147.7	148.1	147.9	124.4	123.3	123.9	3.8	3.8	3.8
Giza 35		35.2	38.1	36.7	107.9	111.2	109.6	134.4	132.8	133.6	3.6	3.6	3.6
Giza 111		42.6	43.3	42.9	127.4	125.4	126.4	145.0	143.7	144.3	3.2	3.1	3.1
L.S.D 0.05		2.78	3.11	1.96	5.02	4.80	3.48	5.35	5.23	4.37	0.95	0.55	0.70
14	DR 101	43.0	46.0	44.5	138.7	143.3	141.0	111.7	108.3	110.0	4.2	4.1	4.1
	H_4	44.0	47.7	45.9	138.7	142.0	140.3	116.7	118.3	117.5	3.4	3.3	3.4
	PI416-937	46.7	51.7	49.2	150.7	150.0	150.3	128.3	126.7	127.5	4.2	4.1	4.1
	Giza 35	35.7	38.3	37.0	109.0	112.3	110.7	138.3	136.7	137.5	4.2	4.0	4.1
	Giza 111	43.0	44.3	43.7	128.0	128.0	128.0	150.0	148.3	149.2	3.5	3.5	3.5
21	DR 101	42.3	46.0	44.2	136.7	142.3	139.5	108.3	105.0	106.7	4.1	4.0	4.1
	H_4	43.3	46.7	45.0	137.3	141.3	139.3	113.3	115.0	114.2	3.3	3.2	3.3
	PI416-937	45.0	51.0	48.0	149.7	149.3	149.5	125.0	123.3	124.2	3.6	3.8	3.7
	Giza 35	35.3	38.0	36.7	108.3	111.0	109.7	135.0	133.3	134.2	3.6	3.5	3.6
	Giza 111	42.7	43.3	43.0	127.3	125.0	126.2	145.0	144.3	144.7	3.3	3.4	3.4
28	DR 101	42.0	44.7	43.3	131.0	141.3	136.2	106.7	101.7	104.2	4.0	3.9	3.9
	H_4	43.0	46.3	44.7	135.3	139.3	137.3	111.7	115.0	113.3	3.2	3.1	3.2
	PI416-937	44.3	48.3	46.3	142.7	145.0	143.8	120.0	120.0	120.0	3.5	3.4	3.5
	Giza 35	34.7	38.0	36.3	106.3	110.3	108.3	130.0	128.3	129.2	3.0	3.2	3.1
	Giza 111	42.0	42.3	42.2	127.0	123.3	125.2	140.0	138.3	139.2	2.7	2.5	2.6
C.V		3.28	3.42	2.23	1.89	1.77	1.30	2.10	2.08	1.73	13.05	7.70	9.68
L.S.D 0.05		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table 5. Means of pods, seeds and seed weight plant^{-1} of studied soybean genotypes as affected by three irrigation intervals and their interactions in both seasons and combined.

Irrigation interval (days)	Genotype	No. of pods plant^{-1} 1^{ST}	No. of pods plant^{-1} 2^{nd}	No. of pods plant^{-1} Comb.	No. of seeds plant^{-1} 1^{ST}	No. of seeds plant^{-1} 2^{nd}	No. of seeds plant^{-1} Comb.	Seed weight plant^{-1} (g) 1^{ST}	Seed weight plant^{-1} (g) 2^{nd}	Seed weight plant^{-1} (g) Comb.
Irrigation interval (days)										
14		79.0	98.2	88.6	169.9	231.1	200.5	25.67	34.864	30.27
21		75.1	94.3	84.7	162.7	221.1	191.9	24.47	31.751	28.11
28		70.7	90.7	80.7	149.7	212.8	181.3	22.99	30.040	26.51
L.S.D 0.05		1.19	4.33	1.68	6.21	8.66	6.56	1.26	N.S	2.47
Genotype										
DR 101		71.9	89.7	80.8	153.2	214.0	183.6	24.04	29.88	26.96
H_4		65.4	85.7	75.6	139.5	192.8	166.2	21.41	26.82	24.11
PI416-937		52.6	74.6	63.6	118.9	161.6	140.3	17.51	21.59	19.56
Giza 35		83.0	98.9	90.9	169.4	257.7	213.6	26.19	38.63	32.41
Giza 111		101.7	123.1	112.4	222.8	282.3	252.6	32.73	44.16	38.45
L.S.D 0.05		9.16	10.77	7.83	15.74	44.00	24.49	6.56	7.32	4.71
14	DR 101	76.8	90.1	83.5	160.1	223.0	191.6	25.03	32.84	28.94
	H_4	66.9	87.5	77.2	146.8	202.3	174.6	22.57	27.94	25.26
	PI416-937	56.5	77.9	67.2	123.4	167.7	145.5	17.97	24.08	21.03
	Giza 35	87.2	101.8	94.5	176.0	262.3	219.2	28.00	41.40	34.71
	Giza 111	107.8	133.7	120.7	240.1	300.3	270.2	34.79	48.06	41.43
21	DR 101	69.6	89.7	79.6	151.9	210.0	180.9	24.42	28.62	26.53
	H_4	64.7	87.0	75.9	141.3	189.0	165.2	21.57	27.07	24.32
	PI416-937	51.0	75.8	63.4	120.8	167.7	144.2	17.36	23.00	20.18
	Giza 35	82.9	99.1	91.0	164.6	258.4	211.5	25.42	37.85	31.64
	Giza 111	107.4	119.7	113.5	234.7	280.3	257.5	33.56	42.22	37.89
28	DR 101	69.5	89.3	79.4	147.6	209.0	178.3	22.65	28.18	25.42
	H_4	64.7	82.5	73.6	130.5	186.9	158.7	20.08	25.45	22.76
	PI416-937	50.2	70.1	60.2	112.8	147.3	130.1	17.21	17.72	17.46
	Giza 35	79.0	95.7	87.4	164.1	252.5	208.3	25.14	36.65	30.89
	Giza 111	89.9	116.1	102.9	193.6	266.3	229.9	29.84	42.21	36.03
C.V		6.03	5.63	4.56	4.83	9.79	6.31	13.27	11.20	8.21
L.S.D 0.05		8.50	N.S	N.S	14.61	N.S	N.S	N.S	N.S	N.S

Table 6. Means of seed index seed yield ton fed^{-1} and LUE of studied soybean genotypes as affected by three irrigation intervals and their interactions in both seasons and combined between them.

		Seed index			Seed yield ton fed^{-1}			LUE		
		1ST	2nd	Comb.	1ST	2nd	Comb.	1ST	2nd	Comb.
Irrigation interval (days)										
14		15.8	15.2	15.5	1.202	1.191	1.197	0.009	0.009	0.009
21		15.6	14.1	14.9	1.089	1.089	1.089	0.009	0.008	0.009
28		15.2	13.9	14.6	1.013	1.022	1.018	0.008	0.008	0.008
L.S.D 0.05		N.S	0.9	0.7	0.03	0.04	0.02	0.0004	0.0004	0.0004
Genotype										
DR 101		15.3	14.4	14.9	1.089	1.048	1.069	0.008	0.007	0.008
H_4		14.9	13.4	14.2	1.019	1.078	1.048	0.007	0.008	0.008
PI416-937		14.2	11.6	12.9	0.622	0.589	0.606	0.004	0.004	0.004
Giza 35		16.0	15.5	15.8	1.248	1.259	1.254	0.010	0.010	0.010
Giza 111		17.1	17.3	17.2	1.530	1.530	1.530	0.014	0.014	0.014
L.S.D 0.05		N.S	3.3	1.8	0.08	0.08	0.06	0.0006	0.0006	0.0006
Irrigation interval (days)	Genotype	Seed index			Seed yield ton fed^{-1}			LUE		
		1ST	2nd	Comb.	1ST	2nd	Comb.	1ST	2nd	Comb.
14	DR 101	15.5	14.9	15.2	1.200	1.156	1.178	0.009	0.008	0.008
	H_4	15.1	13.5	14.3	1.156	1.156	1.156	0.008	0.008	0.008
	PI416-937	14.5	12.2	13.4	0.744	0.722	0.733	0.005	0.005	0.005
	Giza 35	16.1	15.9	15.9	1.344	1.344	1.344	0.010	0.011	0.011
	Giza 111	17.9	19.6	18.7	1.567	1.578	1.573	0.014	0.013	0.014
21	DR 101	15.4	14.4	14.9	1.122	1.056	1.089	0.008	0.007	0.008
	H_4	15.1	13.4	14.2	1.000	1.067	1.033	0.007	0.008	0.007
	PI416-937	14.1	11.4	12.8	0.567	0.544	0.556	0.004	0.004	0.004
	Giza 35	16.1	15.5	15.8	1.222	1.233	1.228	0.010	0.010	0.010
	Giza 111	17.1	16.1	16.6	1.533	1.544	1.539	0.014	0.014	0.014
28	DR 101	15.1	14.1	14.6	0.944	0.933	0.939	0.007	0.007	0.007
	H_4	14.6	13.3	13.9	0.900	1.011	0.956	0.007	0.007	0.007
	PI416-937	14.0	11.2	12.6	0.556	0.500	0.528	0.004	0.003	0.004
	Giza 35	15.9	15.3	15.6	1.178	1.200	1.189	0.009	0.010	0.010
	Giza 111	16.5	16.0	16.3	1.489	1.467	1.478	0.015	0.014	0.014
C.V		14.0	11.3	5.9	3.69	3.68	2.57	4.32	4.90	3.75
L.S.D 0.05		N.S	N.S	N.S	0.08	N.S	0.05	0.0003	0.0007	0.0007

Soil water relations:

Water use

The consumptive use of water (CU) was measured during the season (considered as actual evapotranspiration, i.e., actual ET) as affected by the different treatments and discussed below, as well as water use efficiency (WUE) and water productivity (WP).

Applied irrigation water and water consumptive use Seasonal Rates (m^3 fed^{-1})

Seasonal rates of water consumptive use (CU) by plants soybean as affected by genotypes and irrigation intervals treatments are presented in Table 7.

Table 7. Means of applied irrigation water and water consumptive use as affected by Genotypes and irrigation intervals in 2021 and 2022 seasons.

Irrigation interval days	applied irrigation water m^3 fed^{-1}	Water consumptive use m^3 fed^{-1}					
		Genotype					
		DR 101	H_4	PI416-937	Giza 35	Giza 111	Mean
2021							
14	3525.4	2898.1	2889.7	2851.2	2823.4	2854.2	2863.3
21	3120.4	2589.2	2515.5	2545.1	2587.3	2565.4	2560.5
28	2742.1	2375.3	2371.5	2395.4	2305.9	2310.5	2351.7
Mean		2620.9	2592.2	2597.2	2572.2	2576.7	
2022							
14	3498.7	2702.1	2712.5	2796.4	2855.6	2788.6	2771.0
21	3087.9	2510.1	2579.4	2551.6	2598.2	2574.4	2562.7
28	2786.2	2288.4	2323.4	2314.6	2259.2	2329.1	2302.9
Mean		2500.2	2538.4	2554.2	2571.0	2564.0	

Water use efficiency (WUE):

Total yield per unit of water applied and water consumptive use are the two parameters that are evaluated to determine the water use efficiency. The goal of water use efficiency is to maximize crop yields per unit of irrigation water. Table (8) showed the effect of the different genotypes and irrigation intervals on water use efficiency. The data obtained indicates that the efficiency of water use was greatly impacted by genotypes. In the two seasons under study, the genotypes PI416-937 and H4 had the lowest values of field and crop water use efficiency (0.229 and 0.393 kg m-3, respectively), while the genotypes Giza 111 and Giza 35 had the highest values (0.599 and 0.492 kg m-3, respectively). Additionally, the results showed that water use efficiency rose as water stress increased. In both seasons, the maximum field and crop water use efficiency values (0.444 and 0.433 kg m-3) were obtained with 28-day irrigation intervals.

Giza 111 had the highest field and crop water use efficiencies (0.644 and 0.630 kg m-3) under a 28-day irrigation interval in both seasons, respectively, indicating that the interactions between the factors under study were significant in both seasons, according to the data in Table (8). The highest soybean crop production and lower water use and applied water for this treatment are the primary causes of this. However, the PI416-937 genotype, which was irrigated every 21 days in both seasons, had the lowest values of field and crop water use efficiencies (0.223 and 0.213 kg m-3, respectively). Saving, whereas lend applied water was used and acceptable soybean yield was of trained that equal about 94% of the 14 days interval yield over both seasons.

Table 8. Means of water use efficiency as affected by Genotypes and irrigation intervals in 2021 and 2022 seasons

Irrigation interval (days)	Water use efficiency (kg m^{-3} water)					
	Genotype					
	DR 101	H_4	PI416-937	Giza 35	Giza 111	Mean
2021						
14	0.414	0.400	0.261	0.476	0.549	0.420
21	0.433	0.398	0.223	0.472	0.598	0.425
28	0.397	0.380	0.232	0.511	0.644	0.433
Mean	0.415	0.393	0.239	0.486	0.597	
2022						
14	0.428	0.426	0.258	0.471	0.566	0.430
21	0.421	0.414	0.213	0.475	0.600	0.425
28	0.408	0.435	0.216	0.531	0.630	0.444
Mean	0.419	0.425	0.229	0.492	0.599	

Water productivity (kg m^{-3} applied water)

Water productivity is the term used to characterize the connection between applied water amount and production. In this study, WP values under irrigation every 28 days treatment is higher than the other treatments (irrigation every 14 days and irrigation every 21 days). The highest mean values of WP were recorded under irrigation every 28 absinthe two growing seasons are (0.370 and 0.367kg m^{-3}) in two the seasons respectively (Table 9), while the lowest mean values (0.341 and 0.340 kg m^{-3}) were recorded under irrigation every 14 days treatment in both seasons respectively. Meanwhile, for soybean genotypes, the highest WP (0.493 kg m^{-3}) value was recorded for Giza 111 under irrigation every 28 days treatment in both seasons. The water level and soybean genotypes' over-mean WP values can be increased in the following order: irrigation every 14 days, irrigation every 21 days, and irrigation every 28 days and Giza 111<Giza 35 <DR 101<H_4 < PI416-937 in the two seasons. The Giza 111 soybean variety was the least impacted by the water shortage due to its resilience, and the mean values of WP for irrigation every 28 days and Giza 111 may have increased as compared to other treatments during the two growing seasons. The results obtained are consistent with those of García *et al.* (2020) and He et al.(2017).

Table 9. Means of water productivity as affected by soybean genotypes and irrigation intervals in 2021 and 2022 seasons.

Irrigation interval (days)	Water productivity (kg m^{-3} applied water)					
	Genotype					
	Dr 101	H_4	PI416-937	Giza 35	Giza 111	Mean
2021						
14	0.340	0.328	0.211	0.381	0.444	0.341
21	0.360	0.320	0.182	0.392	0.491	0.349
28	0.344	0.328	0.203	0.430	0.543	0.370
Mean	0.348	0.325	0.199	0.401	0.493	
2022						
14	0.330	0.330	0.206	0.384	0.451	0.340
21	0.342	0.346	0.176	0.399	0.500	0.353
28	0.335	0.363	0.179	0.431	0.527	0.367
Mean	0.336	0.346	0.187	0.405	0.493	

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تقييم بعض التراكيب الوراثية من فول الصويا تحت ظروف نقص الماء

عزه فتحي السيد[١] ، طارق صابر محمد[١]و محمود إبراهيم بدوي[٢]

[١]قسم بحوث المحاصيل البقولية – معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية – مصر
[٢]قسم بحوث المقننات المائية والري الحقلي– معهد بحوث الأراضي والمياه والبيئة- مركز البحوث الزراعية – مصر

الملخص

تم إجراء هذا البحث في المزرعة البحثية لمحطة البحوث الزراعية ,بالجميزة , مصر خلال الموسميين الصيفيين ٢٠٢١و ٢٠٢٢ لاختبار استجابة خمس تراكيب وراثية من فول الصويا (,PI 416-937, DR 101H_4L_4, جيزة ٣٥ , جيزة ١١١) لثلاث معدلات من الري (كل ١٤و ٢١و٢٨ يوم). وقد أظهرت النتائج تفوق الصنف جيزة ١١١ على باقى التراكيب الوراثية في معدلات الري المختلفة من حيث صفات المحصول (عدد القرون ، عدد البذور ، وزن البذور/ النبات ،وزن ١٠٠ بذرة ، محصول البذور/ الفدان بالإضافة إلى كفاءة استخدام الأرض. كما اظهرت معاملة ري الصنف جيزة ١١١ كل ١٤ يوم أفضل معاملة حيث حققت أعلى محصول البذور للفدان. كان هناك زيادة معنوية في عدد القرون ، البذور ، وزن البذور/ النبات ، دليل البذور ، كفاءة استخدام الأرض في نفس المعاملة يليها الري كل ٢١ يوم و ٢٨ يوم . أحدث الري كل ٢١، ٢٨ يوم نقص في محصول البذور ومكوناته مقارنة بالري كل ١٤ يوم. كان معدل النقص فى محصول البذور للفدان نتيجة لإطالة فترات الري من ١٤ يوم (الموصى به) إلى ٢١ و ٢٨ يوم ٢ و٦ % للصنف جيزة ١١١ ، ٩ و١٢ % للصنف جيزة ٣٥ ، ٨ و٢٠ % في DR 101 ، ١١ و ١٧٪ في H_4L_4 ، ٢٤ و ٢٨ % في PI 416-937 .هذا يعنى أنه فى حالة نقص الماء يمكن زراعة الصنف جيزة ١١١ بنجاح في حالة الري على فترات تصل إلى ٢٨ يوم مسجلا أعلى قيمة لكفاءة استخدام الماء وكذلك إنتاجية الماء.