Plant Archives Vol. 20, Supplement 1, 2020 pp. 3102-3111 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF IRRIGATION SYSTEMS AND WEED CONTROL ON THE WATER APPLICATION EFFICIENCY, WEED GROWTH, YIELD, WATER PRODUCTIVITY AND QUALITY OF SOYBEAN CROP UNDER CLAY SOIL CONDITIONS

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Abstract

Field evaluation of the efficiency of two irrigation systems (drip irrigation and surface irrigation by gated pipe) and six weed control treatments (two times hand hoeing, fluazifop - P-butyl, bentazon, butralin, prometryn and unweeded check) and their interaction effects on water application efficiency, weed growth, soybean yield, yield attributes as well as the protein and oil percentages were performed in two successive seasons at Kafer El-Khawazim, Talkha district, Dakahlia Governorate, Egypt. Results revealed that maximum water application efficiency under drip irrigation system was greater than that under surface irrigation system by gated pipes and two times hand hoeing achieved the highest weed depression expressed in the lowest number and dry matter of broadleaved, narrow-leaved and total weeds. Two times hand hoeing was the most superior treatment in increasing plant height, shoot dry weight and SPAD value at 70 days from sowing. Also, seed yield, yield attributes and chemical composition of soybean seeds showed the greatest increments due to the aforementioned treatment followed by that of prometryn treatment. Application of two times hand hoeing provided 90.4 and 95.9% more seed yield than un-weeded check in the firth and second season , respectively. Drip irrigation method recorded the greatest efficiency and reduced the number of broadleaved, grassy and total weeds compared with gated pipes. Drip irrigation increased growth, yield and yield attributes compared with gated pipes. The interaction between irrigation and weed control had significant effects on total dry weight of weeds, growth, yield and yield attributes. Two times hand hoeing or prometryn herbicide integrated with drip irrigation and produced the maximum values of growth, yield and yield attributes. It could be concluded that two times hand hoeing or prometryn combined with drip irrigation could effectively improve growth and productivity of soybean.

***Keywords*:** Drip irrigation, surface irrigation by gated pipe, Herbicides, Growth, Seed yield, Protein and oil, Soybean.

Introduction

Irrigated agriculture, the major contributor of agricultural production, faces thechallenge of improving irrigation water use efficiency and meanwhile ensuring food security (Li *et al*., 2016). The global water consumption for irrigatioin has been steadily growing over the last 50 years and today it makes 70% of all water consumption (Tian *et al.*, 2017). The great challenge of theagricultural sector is to produce more food from less water, which can be achieved by increasing Crop Water Productivity (CWP) (Zwart, 2004). Deficiency of fresh water increases in high places around the worled. According to forecasts of FAO and IFPRI global demand for water resources according to the scenario of usual development by 2030 will increase twice. Improved on farm irrigation systems to deliver adequate timely irrigation to all field plots is necessary to ensure good yield and alleviate any water stress.

In arid countries with large population growth and limitation of fresh water, there is significant pressure on the agricultural sector to reduce water consumption and access to fresh water for the industrial and urban sectors (Abdelraouf and Abuarab 2012). The agricultural sector faces a serious challenge of producing more food with minimal water, which can be achieved by increasing crop water productivity (Abdelraouf *et al*., 2013 c). Increasing crop production is an important national goal to meet the increasing demand for high population growth (Bakry *et al*., 2012). The limited water resources in Egypt led to a severe water scarcity, which is increasing as the population increases. Growing competition for scarce water resources is begging for a new and innovative application of modified irrigation techniques in order to maximize water use efficiency and improve crop yield and quality (Abdelraouf and El Habbasha, 2014, and Marwa, *et al*., 2017). In Egypt, water productivity is of great importance as irrigation water resources are limited and precipitation is a limiting factor (Hozayn *et al*., 2013). Water scarcity is one of the serious and major problems facing crop production in Egypt, and it is necessary to reduce irrigation water consumption by developing new technologies that can fully help to take advantage of these valuable inputs and use them effectively (Abdelraouf *et al*., 2013a,b).). The application of modern irrigation methods is an important concept that must be followed in arid regions such as Egypt to provide a portion of irrigation water due to limited water resources (El-Habbasha *et al*., 2014). Several methods for preserving agricultural water have been explored (Okasha *et al*., 2013). Abo soilman *et al*., (2005) concluded that irrigation by surface gated pipes achieved the highest values of maize and barley grain yields and their components followed by minisprinkler and gun irrigation methods. On the other hand, floppy sprinkler and subsurface drip irritation methods recorded the lowest value of maize yield. While, floppy sprinkler, subsurface and surface drip irrigation methods recoded the lowest values of the obtained yield. Also, they added that drip irrigation recorded the highest value of water distribution uniformity and distribution low quarter while the lowest was obtained under conventional gun and floppy sprinkler methods. Saied *et al*., 2008 indicated that irrigation by surface drip resulted in increasing seed yield of soybean compared with the other irrigation methods. Drip irrigation (DI) promotes emergence of early and amicable shoots of soybean, intensive growth and development of plants, productivity increase (Ospanbayev *et al.*, 2017).

Weed control plays an important role in raising the productivity of crops. The presence of weeds is causing shortage of the crop up to 40% (Soliman *et al.*, 2015). At present, hand hoeing became more expensive than the use of herbicides. Herbicides are cheaper and easier to use weed control than the hoeing. Thus, chemical weed control is necessary to decrease cost and increase soybean productivity. This crop is a large herbicide consumer, and almost of the planted area in Egypt is herbicide-treated. The advantages of herbicide application are characterized by high efficiency in weed control, high selectivity and low cost, compared to other available weed control methods. Soliman *et al.* (2015) indicated that weed control treatments reduced dry weight of broadleaved, grassy and total weeds compared with unweeded treatment. Abd El-Hamed and El-Metwally (2008) and El-Metwally *et al.* (2018) reported that hand hoeing twice scored the lowest value of all weed species and gave the highest values of yield and its attributes of soybean.

Soybean (*Glycine max* L.) is an economical and valuable agricultural commodity due to its unique chemical composition. It is one of the world's most important leguminous crop. It is considered as a good source of high quality plant protein and vegetable oil. Given its high concentration of protein (36-48%), oil (18- 24%), and carbohydrate (20%), soybean is grown in almost all parts of the world for human consumption, industry and animal feed (Boydak *et al.,* 2002). Besides, diets including soybean have been proposed to reduce risk of major diseases such as breast cancer, cardiovascular disease, osteoporosis, diabetes and obesity. The biochemical composition of soybean seeds affected the quality of various soy foods such as soy milk, soy flour, tofu, soy sprouts, soy concentrates and soy isolates. Higher protein and low oil contents are generally desirable characteristics for food users (Kumar *et al.*, 2006). In addition, soybean improves soil fertility through fixing atmospheric nitrogen by *Rhizobium* bacteria in its root nodules (Bakhoum *et al.*, 2019). Hence, two field experiments were conducted to examine the effects of different herbicides and two irrigation methods on weed infestation, yield and its attributes of soybean plant.

Material and Methods

Experimental procedures: Two field experiments were conducted during the two successive seasons 2016 and 2017 at Kafer El-Khawazim, Talkha district, Dakahlia Governorate, Egypt, to examine the effect of irrigation systems and weed control treatments on soybean plants and associated weeds. Experimental soil was clay loam in texture with organic matter 1.78 %, pH 7.79, total N. 0.079 % and available P 14.2 ppm. The experiment was established with a split plot design having four replicates. The main plots included two irrigation systems (drip irrigation and gated pipe). Whereas, the sub-plots were occupied with the six weed control treatments as follows: 1- Two times hand hoeing after 21 and 42 days from sowing. 2-Fluazifop- P-butyl, 3-Bentazon 4-Butralin, 5- Prometryn and 6- Unweeded check. Common, trade, chemical names, rate and application time of the used herbicides were shown in Table 1. The experimental unit was 3.5 X 3.0 m. Soybean seeds (Giza 111) were inoculated with the specific *Rhizobium* strain and immediately sown in hills 25 cm apart on both sides of the ridge. Sowing dates were May 7 and 11 for the two seasons 2016 and 2017, respectively. The normal cultural practices of growing soybean plants were followed normally.

Experimental Design: The experiment was established with a split plot design having four replicates.

Table 1: Common, trade, chemical names, rate and application time of the used herbicides.

Common Name	Trade name	Chemical name	Molecular Formula	Rate of application	Time of application
Fluazifop- P-butyl	Fusalide Super E.C.12.5%	2-[4[445[-(trifluoro-methyl)-2-pyridinyl]oxy]-phenoxy] propanoate	$C_{19}H_{20}F_3NO_4$	2.5 Lha^{-1}	Post emergence after 30 days from sowing
Bentazon	Basagran 48% AS	(3-isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one 2,2-dioxide)	$C_{10}H_{12}N_2O_{3S}$	1.25 L ha^{-1}	Post emergence after 20 days from sowing
Butralin	Amex, 820	4-(1, 1dimethylethyl)-N- 1-methyl propyl)-2, 6-dinitrobenzenamine	$C_{14}H_{21}N_3O_4$	5 L ha^{-1}	Pre-emergence
Prometryn	Gesagard 500 FW	N, Nbis (1-methylethyl-6-(methylthio)-1, 3, 5- triazine – 2, 4-diamine]	$C_{10}H_{19}N_5S$	1.5 L ha^{-1}	Pre-emergence

Estimation of water requirements of soybean: Seasonal irrigation requirements for soybean were obtained from Equation 1, was 3200 and 3300 m^3/fed./season for irrigation by gated pipe for seasons 2016 and 2017 respectively and 1850 and 1900 m^3/fed./season for drip irrigation for seasons 2016 and 2017 respectively. .

$$IRg = [ET_O \times Kc \times Kr] / Ei - R + LR \qquad ...(1)$$

Where IRg = gross irrigation requirements, mm/day, ET_O = reference evapotranspiration, mm/day (estimated from the Central Laboratory for Climate - Agricultural Research Center Egyptian Ministry of Agriculture at El-Nubaryia farm and according to Penman-Monteith equation), Kc = crop factor (Allen et al., 1998), Kr = ground cover reduction factor, Ei = irrigation efficiency, %, R = water received by plant from sources other than irrigation, mm (for example rainfall), LR = amount of water required for the leaching of salts, mm

Evaluation Parameters

Water application efficiency: Water application efficiency (AE_{IW}) is the actual storage of water in the root zone to meet the crop water needs in relation to the water applied to the field. The AE_{IW} was calculated using equation 2:

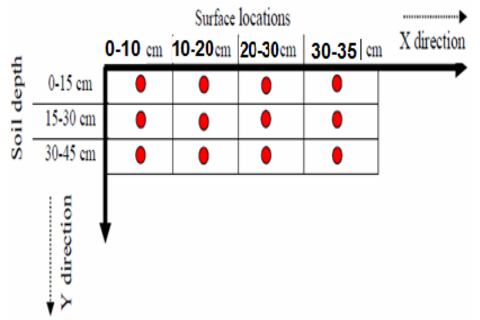
$$AE_{IW} = Ds/ Da \qquad ...(2)$$

Where AE_{IW} is the application efficiency of irrigation water, %, Ds is the depth of stored water in the root zone, cm by equation 3

$$Ds = (\theta 1 - \theta 2) * d * \rho \qquad ...(3)$$

Where: Ds is the depth of applied water (mm), d is the soil layer depth (mm), θ1 is the average of soil moisture content after irrigation (g/g) in the root zone , θ2 is the average of soil moisture content before irrigation (g/g) in the root zone, ρ = bulk density of soil (g/cm^3) as shown as in table 2.

Table 2: Application efficiency of irrigation water at peak of irrigation requirement for soybean

Designs	Soil depth, cm	θ_1 %	θ_2 %	d, mm	ρ, g.mm^{-3}	$D_s = (\theta_1 - \theta_2)*d*\rho$ mm		$D_s = \sum D_{s1} + D_{s2} + D_{s3}$ mm	D_a, mm	$AE_{IW} = [D_s/ D_a]*100$
Drip Irrigation						D_{s1}				
						D_{s2}				
						D_{s3}				
Gated Pipe						D_{s1}				
						D_{s2}				
						D_{s3}				

AE_{IW} = Application efficiency of irrigation water, D_s =Depth of stored water in root zone, D_a =Depth of applied water, d =Soil layer depth, θ_1 =Average of soil moisture content after irrigation, θ_2 = Average of soil moisture content before irrigation, ρ = Relative bulk density of soil (dimensionless).D_{s1}= Depth of stored water in root zone from 0 – 15 cm ,D_{s2}= Depth of stored water in root zone from 15 – 30 cm, D_{s3}= Depth of stored water in root zone from 30 – 45cm

Weed growth: After 70 days from sowing in both seasons, weed samples from one square meter area were randomly collected from each plot. Dry weights of broadleaves, grasses as well as total weeds were recorded after drying in a forced draft oven at 70 °C to constant weight.

Yield of soybean: After 70 from sowing in both seasons samples of five random plants were taken from each experimental plots to determine shoot dry weight and SPAD value of the fourth soybean leaf were determined by chlorophyll meter (SPAD 502, Minolta Camera Co., Osaka, Japan, Minolta Co., 2013).

After maturity, soybean plants were harvested from one middle ridge of each plot on 17th and 25th October in the 1st and 2nd seasons, respectively, to determine plant height (cm), biological yield plant^{-1}(g, pod number plant^{-1}, seed number plant^{-1}, seed yield plant^{-1} (g), 100-seed weight (g), and seed yield (kg fed. $^{-1}$). The seeds were ground to pass a 0.5 mm sieve to determine N and oil contents. Total nitrogen content of the seeds was determined according to AOAC. (1980). Nitrogen values were then multiplied by 6.25 to calculate total crude protein. Oil percentage in soybean seeds was measured by extraction using Soxhlet apparatus with Hexane as an organic solvent, as outlined by AOAC. (1980).

Water Productivity of Soybean "$WP_{soybean}$": The water productivity of soybean was calculated according to James (1988) as follows:

$$WP_{soybean} = Ey/Ir \qquad ...(4)$$

Where $WP_{soybean}$ is water productivity (kg $_{soybean}$ m^{-3}$_{water}$), Ey is the economical yield (kg$_{soybean}$/ha); Ir is the amount of applied irrigation water (m^3$_{water}$/ha/season).

Statistical Analyses: The combined analysis of variance for the data of the two seasons was performed after testing the error homogeneity. The data were then subjected to analysis of variance (ANOVA) according to Gomez and Gomez (1984). The differences among means were compared using Fisher's Least significant difference (LSD) test at 0.05 probability level.

Results and Discussion

Water Application Efficiency

Water application efficiency under the drip irrigation system and surface irrigation system by gated pipes was studied. Logically, the added efficiency values under the drip irrigation system were much greater than the efficiency of surface irrigation using the gated pipes, and this resulted from the amount of water stored in the root-spreading area for the amount of water added is much greater under the drip irrigation system compared to the surface irrigation system using gated pipes, which will have a positive and health impact on the water stress that will be exposed to the roots of crops grown under the drip irrigation system as shown as in figure 1.

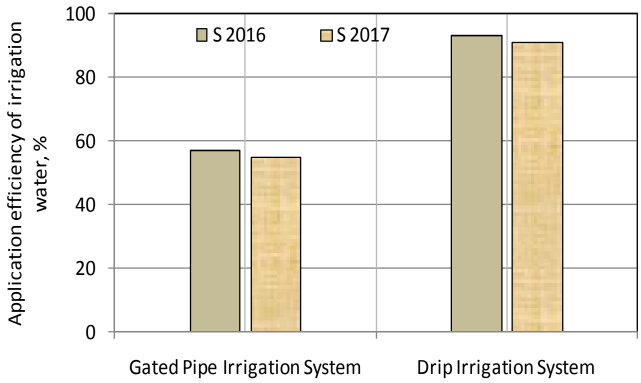


Fig. 1 : Water application efficiency under drip and gated pipes irrigation systems

Weeds Growth

The most commonly surveyed weeds in the experimental field through the two growing seasons were: grasses comprising Jungle rice (*Echinochloa colonum*), Bermudagrass (*Cynodon dactylon*) and Purple nutsedge (*Cyperus rotundus*) and broadleaved weeds comprising purslane (*Portulaca oleraceae*), Nalta jute (*Corchorus olitorius*) and Venice mallow (*Hibiscus trionum*).

The results of two irrigation methods presented in Tables 3 and 4 showed significant effect on number and dry weight of broadleaves, grassy and total weeds after 70 days from sowing. Gated pipes method recorded the maximum values of the previous parameters. Drip irrigation method recorded the greatest efficiency and reduced the number of broadleaves, grassy and total weeds by 14.14, 10.40 and 12.30% in the first season and 26.52, 28.95 and 28.18 % in the second season, respectively, compared with gated pipes. Also, drip irrigation method recorded the greatest efficiency and reduced the dry weight of broadleaves, grassy and total weeds by 12.98, 14.32 and 13.49% in the first season and 27.16, 29.31 and 28.22 in the second season, respectively compared with gated pipes. This result may be due to gated pipes provides the plants with more water, which leads to more weed growth compared to drip irrigation.

All weed treatments significantly reduced the number and dry weights of broadleaves, grasses and total weeds compared with weedy check control treatment (Tables 3 and 4). Hand hoeing was the most effective treatment on number and dry weight of broadleaves weeds, while bentazon was the most effective herbicide treatment followed by prometryn in both seasons. Also, hand hoeing, fluazifop- P-butyl and prometryn recorded the greatest efficiency and reduced the number, dry weight of grassy weeds in the second and first seasons. Moreover, hand hoeing, prometryn and butralin recorded the maximum efficiency and reduced the number of total weeds by 89.73, 78.69, 74.73% in the first season and 89.64, 79.06 and 72.86% in the second season, respectively as well as reduced dry weight of total weeds by 90.43, 79.62 and 75.45% in the first season and 90.23, 79.34 and 72.76% in the second season, respectively compared with the un-weeded control. Several reports have confirmed that hand hoeing twice is the most effective weed control practice for reducing weed dry matter accumulation in faba bean and soybean fields (El-Metwally, 2016 and El-Metwally *et al.*, 2018). Thus, prometryn was more effective in controlling total weeds after hand hoeing and resulted in the highest reduction in number and dry matter of weeds when compared with butralin, bentazon and fluazifop- P-butyl. The reduction of weed dry weight may be due to the inhibition effect of herbicide treatments on growth and development of weeds. Our findings are consistent with those obtained by El-Metwally *et al.,* 2017.

Significant interaction effect was found between irrigation methods and weed management on the number and dry weight of broadleaves, grasses and total weeds (Tables 3 and 4). Using of drip irrigation resulted in the lowest values of previous parameters when two hand hoeing was applied in both seasons. In this regard, the plots which irrigated with gated pipe and un-weeded treatments produced the maximum values of number and dry weight of weeds.

Table 3: Effect of irrigation systems and weed control treatments on number and dry weight of broadleaves and grasses weeds during seasons 2016 and 2017

Treatment	No. of Broad leaves			Weight of broadleaves (g)			No of grasses			Weight of grasses (g)		
	First season											
	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean	S1	S2	Mean
H. hoeing	7.4	8.3	7.9	11.5	12.7	12.1	11.9	12.1	12.0	21.9	22.2	22.1
Fluazifop.	36.8	39.4	38.1	67.1	70.2	68.7	13.2	15.5	14.4	25.3	29.9	27.6
Bentazon	9.3	12.7	11.0	15.5	20.9	18.2	51.7	55.9	53.8	95.7	105.7	100.1
Butralin	15.2	19.8	17.5	24.7	30.8	27.8	30.1	33.8	31.9	57.1	62.8	60.0
Prometryn	13.9	15.9	14.9	20.1	27.7	23.9	24.9	27.9	26.4	45.7	52.1	48.9
Control	70.6	82.0	76.3	130.8	147.3	139.1	111.2	125.7	118.5	195.9	240.3	219.2
Mean	25.5	29.7		44.9	51.6		40.5	45.2		73.6	85.9	
LSD 5%												
Irrig. Syst. (S)		1.7			3.1			1.7			2.5	
W. control (W)		2.0			4.6			4.7			4.7	
SXW		2.8			6.6			N.S.			6.6	
Second season												
H. hoeing	6.5	9.3	7.9	10.1	14.0	12.1	9.9	13.7	11.8	17.7	25.1	9.3
Fluazifop	32.7	41.7	37.2	60.8	75.3	68.1	10.7	17.6	14.1	19.8	31.5	41.7
Bentazon	7.3	14.2	10.8	11.9	25.1	18.5	45.7	60.2	53.0	84.7	111.2	14.2
Butralin	13.8	21.1	17.5	21.5	37.2	29.4	26.6	41.7	34.2	50.3	77.8	21.1
Prometryn	11.7	17.3	14.5	18.8	31.4	25.1	19.7	30.9	25.3	35.2	56.4	17.3
Control	65.9	84.2	75.1	120.1	150.6	135.4	97.8	132.2	115.0	175.9	240.3	84.2
Mean	23.0	31.3		40.5	55.6		35.1	49.4		63.9	90.4	
LSD 5%												
Irrig. Syst. (S)		0.8			0.8			5.7			10.1	
W. control (w)		2.4			3.8			3.5			7.8	
SXW		3.4			5.4			4.9			12.0	

S1: Drip irrigation, S2: Surface Irrigation by gated pipes

Table 4: Effect of irrigation systems and weed control treatments on total number and dry weight of weeds during seasons 2016 and 2017.

Treatment	Total No. of weeds			Total weight of weeds		
First Season						
	S1	**S2**	**Mean**	**S1**	**S2**	**Mean**
H. hoeing	19.5	20.4	20.0	33.4	34.9	34.2
Fluazifop.	50.1	54.9	52.5	92.4	100.1	96.3
Bentazon	58.1	68.6	63.4	111.2	126.6	118.9
Butralin	44.8	53.6	49.2	81.8	93.6	87.7
Prometryn	39.2	43.8	41.5	65.8	79.8	72.8
Control	181.7	207.7	194.7	326.7	387.7	357.2
Mean	**65.6**	**74.8**		**118.6**	**137.1**	
LSD 5%						
Irrig. Syst. (S) W. control (W) SXW	1.5 6.1 3.8			3.6 8.4 8.9		
Second season						
H. hoeing	16.4	23.0	19.7	27.8	39.1	33.5
Fluazifop.	43.4	60.3	51.9	80.6	107.1	93.9
Bentazon	53.0	74.4	63.7	99.1	136.3	117.7
Butralin	40.4	62.8	51.6	71.9	115.0	93.5
Prometryn	31.4	48.2	39.8	54.0	87.8	70.9
Control	163.7	216.4	190.1	295.5	390.9	343.2
Mean	**58.1**	**80.9**		**104.8**	**146.0**	
LSD 5%						
Irrig. Syst. (S) W. control (W) SXW	3.1 2.8 7.5			5.8 10.4 4.7		

S1: Drip irrigation, S2: Surface Irrigation by gated pipes

Yield and its attributes of soybean

The results in figure 2 and tables 5 and 6 indicated that the effect of two irrigation methods on yield and yield attributes of soybean significantly affected number of pods, number of seed, seeds weight / plant, biological yield ton fed.$^{-1}$/ and seed yield ton fed.$^{-1}$. Drip irrigation gave the best values of the previous parameters as compared to gated pipe. Drip irrigation increased seed yield amounted to 1.1 and 28.2 % in the first and second seasons, respectively as compared with gated pipe. In this regard, the increase in seed yield may be due to increase in the vegetative growth, which led to increase the yield components resulting in increased plant seed yield. These results are in coinciding with those detected by Adeboye *et al*., 2015 and Ospanbayev *et al.,* 2017.

Concerning the effect of weeded practices on yield and its attributes, all weeded plots produced more yield over the weedy control treatment. Applying two times hand hoeing resulted in increasing number of pods, number of seed, seeds weight/plant, 100 seed weight and seed yield by 101.4, 86.0, 91.7, 27.4 and 90.4% in the first season and 57.3, 73.6, 95.1, 21.1 and 95.9 % in the second season over the weedy control, respectively. Such treatment minimized weed-crop competition (Tables 3 and 4) and saved more of the available resources for improved crop growth. Thus, this treatment increased plant height and resulted in greater straw and seed yields. The positive effect of weed control on soybean yield and its components have been confirmed by Kunz and Gerhards (2016) and Gidesa and Kebede (2018).

Data in tables 5 and 6 showed that there was a significant effect due to the interaction between irrigation methods and weed control on seed yield and its attributes. Drip irrigation significantly increased seed yield its attributes when two hand hoeing was applied compared with the other treatments. Results also indicated that drip irrigation combined with Prometryn was slightly less effective but not significantly so, the lowest grain yield was recorded with the un-weeded treatment and gated pipe method.

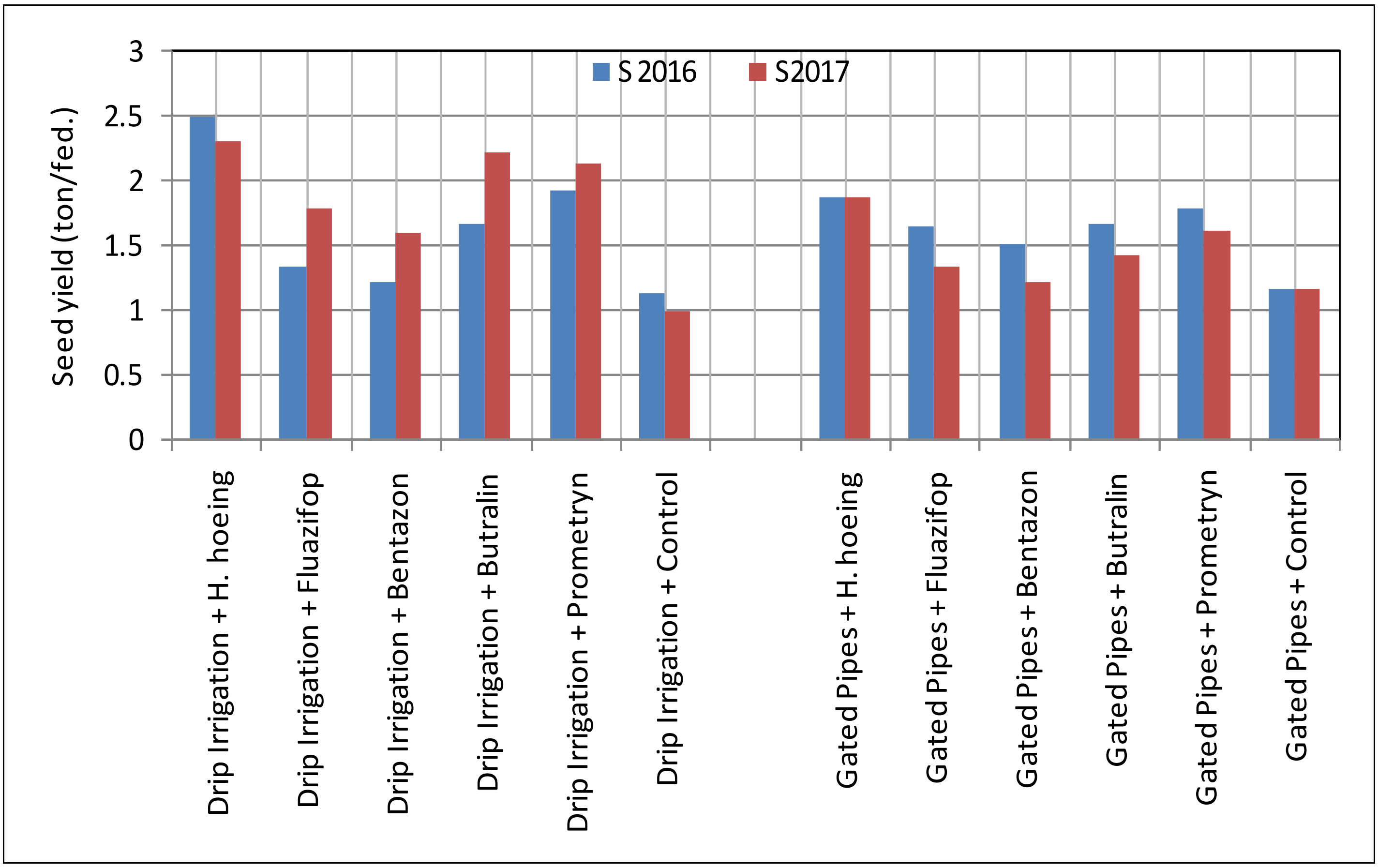


Fig. 2 : Effect of irrigation system and weed control treatments on seed yield of soybean during seasons 2016 and 2017

Table 5: Effect of irrigation system and weed control treatments on yield components of soybean during seasons 2016 and 2017.

Treatment	**No of pods/plant**			**No on seeds /plant**			**Weight of seeds /plant**			**1 00 seeds weight**		
	First season											
	S1	**S2**	**Mean**	**S1**	**S2**	**Mean**	**S1**	**S2**	**Mean**	**S1**	**S2**	**Mean**
H. hoeing	100	76.3	88.2	198.8	151.3	175.0	28.8	21.8	25.3	17.7	16.6	17.2
Fusilad	57.0	74.0	65.5	157.5	149.0	153.3	15.0	18.3	16.7	13.5	15.0	14.3
Basagran	46.5	65.0	55.8	123.8	121.0	122.4	12.5	17.5	15.0	13.4	14.4	13.9
Butralin	82.3	31.3	56.8	200.0	105.0	152.5	18.8	18.8	18.8	16.0	13.9	15.0
Gizagrad	61.3	66.5	63.9	149.3	163.0	156.1	26.3	20.0	23.1	16.1	16.4	16.3
Control	40.0	47.5	43.8	98.8	89.4	94.1	11.8	14.6	13.2	13.3	13.6	13.5
Mean	64.5	60.1		154.7	129.8		18.9	18.5		15.0	15.0	
LSD 5%												
Irrig. Syst. (S)	3.1			3.9			N.S.			NS		
W. control (W)	5.9			9.3			2.4			1.2		
SXW	8.3			6.6			3.4			NS		
	Second season											
H. hoeing	68.8	58.0	63.4	155.0	152.5	153.8	21.3	26.8	23.8	17.5	18.1	17.8
Fusilad	88.8	78.8	83.8	100.0	212.5	156.3	15.0	20.3	17.7	16.6	16.1	16.4
Basagran	88.8	63.8	76.3	108.8	133.8	121.3	13.5	18.3	15.9	16.1	15.9	16.0
Butralin	58.0	62.5	60.3	146.8	118.8	132.8	16.3	25.0	20.7	15.9	15.2	15.6
Gizagrad	50.0	57.5	53.8	120.0	150.0	135.0	18.8	24.8	21.8	17.2	16.5	16.9
Control	38.8	41.8	40.3	93.8	83.3	88.6	13.0	11.3	12.2	14.3	15.1	14.7
Mean	65.5	60.4		120.7	141.8		16.3	21.1		16.3	16.2	
LSD 5%												
Irrig. Syst. (S)	4.9			6.2			1.4			NS		
W. control (W)	6.3			11.2			2.4			1.6		
SXW	3.4			15.9			3.4			NS		

S1: Drip irrigation, S2: Surface Irrigation by gated pipes

Table 6: Effect of irrigation system and weed control treatments on the biological and seed yield of soybean during seasons 2016 and 2017.

Treatment	Biological yield (ton/fed.)			Seed yield (ton/fed.)		
	First season					
	S1	S2	Mean	S1	S2	Mean
H. hoeing	5.04	4.52	4.780	2.49	1.87	2.180
Fluazifop	3.50	3.11	3.305	1.33	1.65	1.490
Bentazon	3.56	3.09	3.325	1.21	1.51	1.360
Butralin	4.44	3.55	3.995	1.67	1.67	1.670
Prometryn	4.96	4.11	4.535	1.92	1.78	1.850
Control	2.53	2.43	2.480	1.13	1.16	1.145
Mean	4.01	3.47		1.625	1.607	
LSD 5%						
Irrig. Syst. (S) W. control (W) IXW	0.038 0.065 0.004			0.029 0.039 0.054		
	Second season					
H. hoeing	4.89	4.26	4.577	2.31	1.87	2.090
Fluazifop.	3.51	3.22	3.365	1.78	1.33	1.555
Bentazon	3.44	3.09	3.265	1.60	1.21	1.405
Butralin	4.07	3.41	3.740	2.22	1.42	1.820
Prometryn	4.30	4.00	4.150	2.13	1.61	1.869
Control	2.27	2.74	2.505	0.98	1.16	1.067
Mean	3.75	3.45		1.837	1.433	
LSD 5%						
Irrig. Syst. (S) W.control (W) SXW	0.026 0.043 0.002			0.026 0.023 0.034		

S1: Drip irrigation, S2: Surface Irrigation by gated pipes

Water Productivity of Soybean

One of the most important evaluation criteria is the study of water productivity when the primary goal is to provide irrigation water. When studying the water productivity of the soybean crop under the drip irrigation and surface irrigation systems using the gated pipes, it was found that the water productivity values took the same direction of productivity from the seed yield, and this is logical due to the stability of the amount of water added under the drip irrigation system and the stability of the amount of water added under the surface irrigation system using gated pipes. The highest values of water productivity of soybean were under the drip irrigation system and weed control using hand hoeing compared to the rest of the other parameters as shown as in figure 3.

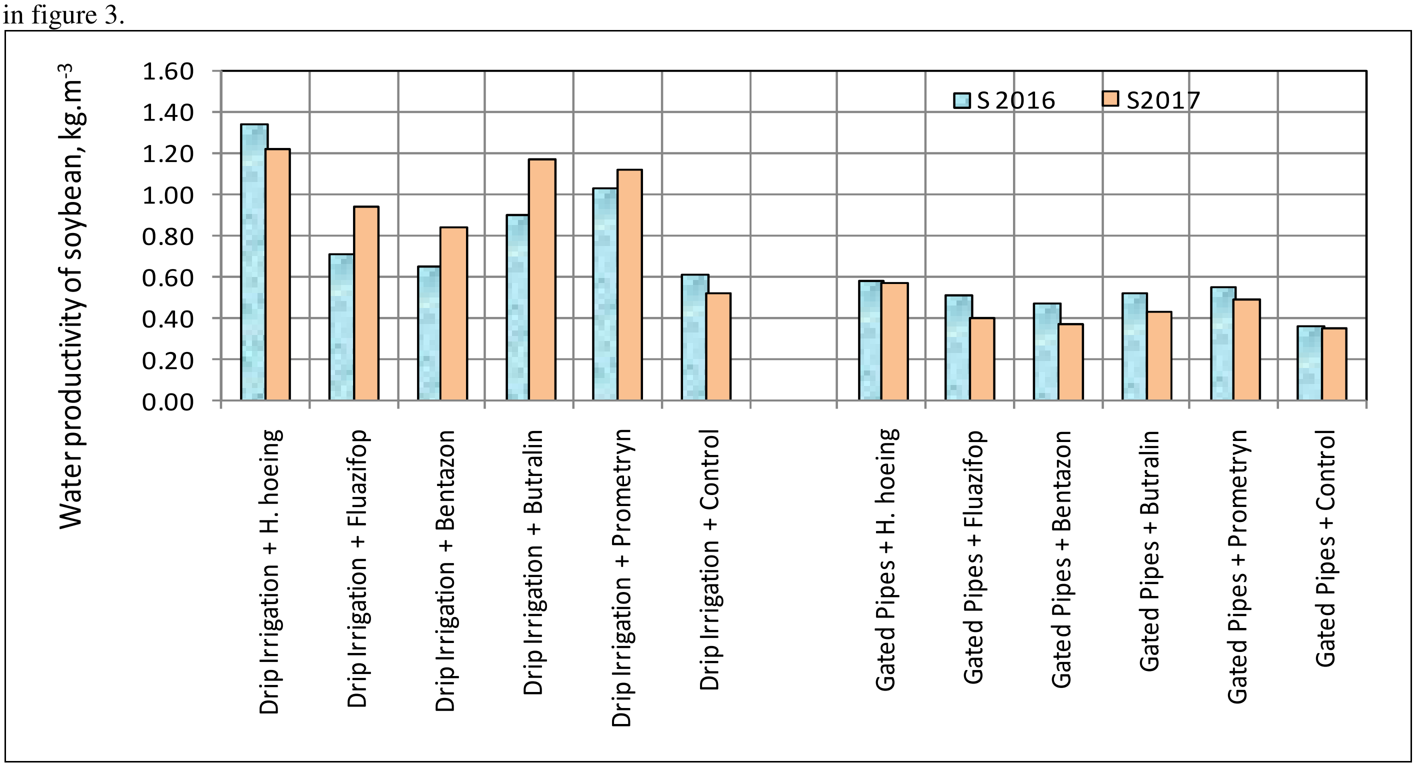


Fig. 3 : Effect of irrigation system and weed control treatments on water productivity of soybean during seasons 2016 and 2017

Grain Chemical analysis of soybean seeds

The concentrations of protein (%) and oil (%) were appreciably influenced by irrigation methods (Table 7). Drip irrigation gave the highest values of the protein and oil as compared to gated pipes method. The increase in content of seeds protein % and oil% with drip irrigation may be due to promote the growth which can enable plants to absorb more nutrients for shoot growth which may be reflected on nutrients status in seeds of soybean. Data in table 7 showed that all weed control treatments caused significant increases in oil and protein over the un-weeded check. Maximum values of oil and protein were obtained by two times hand hoeing followed by Prometryn and butralin treatments. In this regard, no significant differences between herbicides treatments. While, the lowest values of the aforementioned parameters were recorded when soybean were un-weeded. The aforementioned increases in oil and protein in soybean seeds may be due to less competition for environmental factors, particularly nutrients, water and light through limiting weeds infestation with herbicidal treatments due to increasing the uptake of different nutrients and reflected on chemical composition of seeds. The positive effects of weeded practices on chemical analysis of soybean seeds have been confirmed by Abd El-Hamed and El-Metwally (2008) and ElMetwally (2016). It could be concluded that two times hand hoeing or Prometryn combined with drip irrigation achieved the maximum values of seed yield / unit area under the environmental conditions of Dakahlia Governorate, Egypt.

Table 7: Effect of irrigation system and weed control treatments on protein % and oil % during seasons 2016 and 2017.

Treatment	Protein %			Oil %		
	First season					
	S1	S2	Mean	S1	S2	Mean
H. hoeing	37.6	38.6	38.1	27.5	27.5	27.5
Fluazifop	36.3	36.8	36.6	25.9	26.2	26.1
Bentazon	36.1	36.7	36.4	25.5	25.5	25.5
Butralin	36.7	37.3	37.0	26.4	26.3	26.4
Prometryn	37.0	37.7	37.4	27.0	27.3	27.2
Control	34.3	35.1	34.7	24.0	24.4	24.2
Mean	36.3	37.0		26.0	26.2	
LSD 5%						
Irrig. Syst. (S)	0.4			NS		
W. control (W)	0.4			0.2		
IXW	NS			NS		
	Second season					
H. hoeing	38.7	38.9	38.8	27.5	28.0	27.7
Fluazifop.	36.9	36.9	36.9	25.3	26.2	25.8
Bentazon	37.0	36.5	36.8	25.8	26.3	26.1
Butralin	37.2	37.8	37.5	26.6	27.0	26.8
Prometryn	38.1	38.5	38.3	27.3	27.7	27.5
Control	35.1	35.2	35.1	24.8	25.1	24.9
Mean	37.2	37.3		26.2	26.7	
LSD 5%						
Irrig. Syst. (S)	NS			0.2		
W.control (W)	0.4			0.2		
SXW	NS			NS		

S1: Drip irrigation, S2: Surface Irrigation by gated pipes

Conclusion

Values of water use efficiency under the drip irrigation system were much greater than the efficiency of surface irrigation using the gated pipes, which will have a positive impact on the water stress that will be exposed to the roots of crops grown under the drip irrigation system.

Two times hand hoeing was the most superior treatment in increasing plant height, shoot dry weight and SPAD value. Also, seed yield, yield attributes and chemical composition of soybean seeds showed the greatest increments due to the aforementioned treatment followed by that of prometryn treatment. Application of two times hand hoeing provided 90.4 and 95.9% more seed yield than un-weeded check. Drip irrigation method recorded the greatest efficiency and reduced the number of broadleaved, grassy and total weeds compared with gated pipes. Drip irrigation increased growth, yield and yield attributes compared with gated pipes. The interaction between irrigation and weed control had significant effect on total dry weight of weeds, growth, yield and yield attributes. Two times hand hoeing or prometryn herbicide integrated with drip irrigation and produced the maximum values of growth, yield and yield attributes. It could be concluded that two times hand hoeing or herbicide prometryn combined with drip irrigation could effectively improve growth and productivity of soybean.

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