Yield Response of Soybean Crop to Irrigation Regime and Planting dates in El-Minia Region – Middle Egypt

Abdel Reheem, H. A.; Ahmed, Y. M.; Mohamed, M. A. and Hassan, A. F.

Water Management Research Institute, National Water Research Center, Delta Barrages. Egypt
dr.hassanahmed_999@yahoo.com

Abstract: Two field experiments were carried out at Mallawy Research Station, El-Minia province, Middle Egypt during the growing summer seasons of 2015 and 2016 to evaluate the effect of sowing dates and irrigation regime on water applied, actual water requirements, saving water and yield for Soybean crop (**Glycine max L.**). The experiments included four treatments of sowing dates (A) and two irrigation regime (B) with four replicated. The irrigation regime treatments were traditional irrigation (the farmers practices), 100%, 90%, 80% and 70% of field capacity). Sowing dates were distributed at random in the main plots while irrigation regime treatments were distributed at random in the sub- plots so that the experiment was arranged in a split plot design. The results indicated that the highest values were obtained from plants which sowing at 10th May and irrigated until 80% of field capacity A_1b_4 (1.760 ton / fed.). The treatment A_1b_4 was the best (from with regard to the water saving) it can save irrigation water by about 635.45 m^3/fed equal (18.96%) under El-Minia conditions, compared with the common conventional treatment. The results show also that, the amount of water irrigation which can be saved (average area cultivated by soybean in El- Minia region) about 76254000 million m^3/ area compared to conventional treatment in region. Treatment A_1b_4 (planting at 10th May and irrigated until 80% of field capacity) gave the highest values of production and water use efficiency.

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1. Introduction

In arid and semi- arid regions as prevailing in Egypt, where water resources are very limited, the maintenance of water resources is one of the most important national aims to face the great needs. So irrigation management is very important nowadays owing to shortage in irrigation water as a result of the increase of human and agricultural consumption especially with the expansion of agriculture in the newly reclaimed lands. Therefore, it is necessary to determine the optimum water requirement and planning the best irrigation regime for obtaining maximum yield, More attention was paid to maintain the water resources by minimizing the losses, decreasing the water consumption and indicating the best schedule soybean irrigation for farmers. On the other hand Soybean ***(Glycine max L.)*** is the most important crops for obtaining oil and protein in the world. Its seeds have the highest protein content among leguminous crops. The nutritional value of soybean protein is the best available plant protein sources, because it contains a high ratio of the essential amino acids. Its oil is used either directly in the human consumption or indirectly in the many manufactured valuable materials Indeed, soybean seeds has many uses such as, human food, animal feed. However, soybean plants foliage can be used as hay, pasture, cover and green manure crop. A high yield of soybean per unit area is the aim of agronomists and farmers under the limited area and water resources. This goal can be achieved by cultivating high yielding cultivars coupled with application of the best package from agricultural practices including optimum levels of several factors. Among these factors, which affect growth and productive phase of soybean are sowing dates and irrigation regime.

Many investigators showed the effect of sowing date on yields and water relationships of Soybean crop **Grisssom et al (1955**) found that water relations which include consumptive use plants in Mississipi, U.S.A., reached to 6.4,7.0 and 6.3 inches for June, July and August, respectively. **Brouwer (1959)** pointed out that irrigation of soybean plants during flowering increased the pod number, the number of seeds per pod and the 1000 seeds weight. **Uklein (1961)** found that the maintenance of soil moisture at 80% of field capacity throughout the vegetative growth resulted in high yield of soybean. He stated also that irrigation during crop emergence, at flowering and filling of the beans was also important factor in raising yield. **Hulpoi et al (1970**) found that average daily crop water consumptive was 4.5-5.0 mm and highest daily water consumptive in July was 6.7-7.1mm. **Khvan (1971)** in USSR, in pot trials with soybeans showed that a height soil moisture content

120-135% of field capacity, during the growth period inhibited growth showed down chlorophyll synthesis and changed leaf morphology and decreased dry matter accumulation and seed yields. **Lutz et al. (1973)** found that irrigation increased lodging of soybean plant and seed size but delayed maturity. Seed yield was highest on irrigation plots when compared with no irrigation. **Russell (1973**) reported that water deficits can reduced yields seriously if it occur at certain critical growth period. The most usual critical period is during flower formation and fertilization for pollen production and viability can be reduced by a deficit at this time. **Campbell and Phone (1977)** too much moisture tends to reduce O_2 concentrations in the soil and thus lower crop yields. **Thampson (1977**) in Australia, found that the water use of soybean C.V. Cleck 63 and Shelby under furrow irrigation was 730 mm. **Saenko (1977)** found that irrigation at the depletion of soil moisture content to 60, 70 or 80 % field capacity gave average seed yield of 1.42,.1.93 and 2.53t/ ha. respectively, compared with 0.71t/ ha. without irrigation.

Cure et al. (1983) stated that water stress reduced seed yield of soybean by 33%. The duration of seed filling under day was not affected by the water stress and seed yield was reduced by 19% only. **El-Sherbieny (1983)** studied the effect of two sowing dates i.e., early sowing (April 26th) and late sowing (June 15th) on growth, yield, yield components and seed chemical composition. He showed that late sowing gave the tallest plants, but early sowing gave higher number of branches and leaves and total dry weight / plant than the late sowing. However, seed yield per plant and fadden, 1000-seed weight reached to its maximum values with sowing soybean at early date, likewise, straw yield/ feddan was decreased with delaying sowing date with no significant differences between the two sowing dates. Moreover, he added that delaying sowing date significantly increased crude protein percentage, while seed oil percentage took the reverse trend. **Ramseur et al. (1984)** pointed that yields were significantly increased with irrigation, whereas, increases in seed number under the irrigation treatments were due to increase number of pods / plant and seeds/ pod compared with nonirrigated treatment (under rainfall conditions). **Sarmah et al. (1984)** in India, tested the effect of sowing date on five soybean varieties. They indicated that seed yield was significantly influenced by different dates of sowing. The early date i.e May 16th produced significantly the highest seed yield compared with the other dates of sowing (June 30th, July 22th and August 20th) The delay in sowing beyond May resulted in appreciable reductions in seed weight per plant and seed yield per hectare. **Brooks (1986)** studied the effect of two sowing dates (May and June) on soybean cultivars. He noticed that intercepted energy during the period extending from plant emergence to physiological maturity was greater when soybean was planted on May. **Cox and Jolliff (1986)** observed that pod number among yield components was the most sensitive to soil water deficit. **Eweida et al. (1986)** determined the yield and some agronomic characters of two soybean cultivars sown at 20 days interval extending from April 1st to June 1st. They showed that 100- seed weight and seed oil percentage were decreased with delaying planting from April 1st to June 1st. Sowing on May 10th gave higher number of pods and seeds per plant as well as seed yield / feddan. **Ali (1989)** in comparing the response of four soybean varieties to four sowing dates started from May 1st with three weeks intervals, he found that sowing during the second half of May produced significantly higher yields of seeds, oil and protein per feddan. Similarly, plant height, number of pods and seeds per plant, seed index and seed weight / plant were maximized with the same date of sowing. Seed oil content was decreased, while seed protein content was increased with delaying in sowing. **Moore et al. (1991)** determined seed yield of two soybean cultivars sown at three planning dates (May through June) They found no significant difference between cultivars with May sowing, but the differences in productivity were significant when sowing was practiced on June. In general, May planting out yielded other sowings. **El-Sherbieny (1992)** studied the effect of three planting dates at one month interval starting on March 25th on growth, yield, yield components and seed quality. He found that the highest seed and straw yield / feddan, seed yield per plant, number of branches, pods and seeds / plant, 100-seed weight number of leaves per plant, leaf area /plant, leaf area index and dry weight /plant were obtained when soybean seeds were sown on April 25th. However seed protein percentage was significantly increased with delaying sowing date, the reverse trend was obtained regard to seed oil percentage and plant height. **Mohamed (1994)** studied the response of six soybean genotypes to two sowing dates (May 15th and June 15th) He found that plant height, number of branches and pods per plant, number of seeds per pod, seed weight / plant, height of the first pod, number of fruitful nodes (clusters) per main stem, weight of 100 seeds (seed index), seed and straw yields, seed oil percentage and oil yield / feddan were significantly increased with sowing on May 15th compared to sowing on June 15th. However, seed crude protein percentage was increased with delay in sowing date. **Elmore (1990)** studied the performance of six soybean cultivars planted on early, late May and mid June. He mentioned that seed yields were 2.72 and 3.14 ton/ ha for sowing on May 7th and

May 29th, respectively. **El –Attar (1993)** tested the effect of six soybean genotypes to six planting dates, i.e. early –April, mid- April, early –May, mid –May, early –June and mid June. He showed that delaying the date of planting decreased plant height, number of branches and pods / plant and seed yield / plant. However, planting date did not affect number of seeds / pod and seed index. **El-Karamity (1996)** show that delay in sowing date for April 1st to June 1st increased plant height, while seed oil percentage was decreased. However, the greatest number of pods/ plant, 100-seed weight and seed yield / feddan were resulted on May 1st sowing. **Abu-Zaid (1998)** studied the effect of three sowing dates (April 15th, May 15th and June 15th) on yield, yield components and seed chemical contents of soybean (Clark cultivars). He indicated that plant height, straw yield per feddan and seed oil percentage were significantly increased with earliness in sowing from June 15th to April 15th. However, sowing on May 15th gave the highest values for number of branches and pods / plant, seeds /pod, seed yield /plant,100-seed weight (seed index) and seed yield / feddan. On the other hand, height of first pod and seed protein percentage were increased with delay in sowing date. **Bhatia et al (1999)** they study the effect of sown on 5 dates between 20 June and 30 July on 12 soybean cultivars. They found that significant differences for yield and most of the yield components among sowing dates and cultivars. Yields decreased with delay in sowing. **Shams El- Din et al (1997)**:, **Elsa el al, (1998) and Hassan el al (2002)** found significant differences among soybean varieties in seed index, plant height, number of pods and seeds per plant and seed yield. They reported that seed yield of cultivars decreased with delayed sowing. They added the higher yields were associated with more pods and higher seed weight per plant as well as heavier weight of 100 seeds date. **Al-Tawaha et al (2007)** studied the effects of different irrigation levels on soybean yields, oil and protein content, and other major agronomic characteristics in Quebec, Canada. They found that irrigation treatments generally resulted in higher yields, compared to the rain fed treatment that served as a control. **Demirtas et al (2010)**: studied the effect of response of soybean (Glycine max "L." Merr.) to drought at various stages of development in a sub-humid environment of Turkey. They found that when plants were droughted during the seed filling stage. Yield increased exponentially with crop water use and ranged from 2.1 -2.5 tons/ ha in non –irrigated plants to 3.5-4.0 tons/ ha in the well-watered controls. However, plants droughted during the vegetative stage of development produced the highest yield per unit of irrigation water applied (that is, irrigation water use efficiency). This research results will be useful for maximizing soybean production and / or seed when irrigation water is limited. **Comlekciog and Simsek (2011)**. studied the effect of the water deficit on yield and yield components of soybean in semi-arid conciliations. this research was carried out as the Agricultural Experimental Field of the Harran University (Sanliurfa. Turkey) on clay soil during the growth periods of 2006 and 2007. The irrigation treatments were 33% (I_{33}), 67% (I_{67}).100% and 133% (1_{33}) ratios of total irrigation water applied (IW)/ cumulative pan evaporation (EPE) with four day irrigation interval. The average amount to irrigation water applied to treatments (I_{133}. I_{100}. I_{67} and I_{33}) was 1058, 795, 533 and 263mm and 1094, 823, 551 and 272mm for Toyokomachi and Toyohomare cultivars, respectively. Yield response factor (k_y) values of I_{100} I_{67} and I_{33} treatments were determined as 2.17, 0.92 for Toyohomare and 3.50.0.61 and 0.61 and 0.61 for Toyokomachi, respectively. They recommended that at least equal (I_{100}) or excess of the evaporated water amount is required to produce high yield in soybean. Differences of yield between cultivars in response to irrigation levels make it necessary to select less sensitive cultivars to water stress especially in semi-arid and arid areas. Varietal characteristics must be considered for successful growing of soybean. **Kresovic et al (2017)** studied the effect of irrigation regimes on soybean seed the irrigation treatments included: no irrigation; full irrigation (I100); and two deficit irrigation treatments – 65% of I100(I65) and 40% of I100. The irrigation treatments generally had a statistically significant effect on the increase of soybean yield and protein content. Irrigation did not have a significant effect on the oil content. The results show that irrigation with the largest amount of water (treatment I100) provided no po-tential benefit in terms of soybean yield and chemical composition. Treatment I65, which exhibited the most favour-able watering conditions, is the best choice to maximize yield and ensure a good chemical composition of soybean under these agroecological conditions. Now water is fast becoming an economically scarce resource in many areas of the world especially in arid and semi-arid regions. In Egypt, there are many plants for increasing cultivable land and agriculture production to overcome problems of the food security Therefore, the water element and sowing dates are of the important factors that affect the productivity and quality of crops, under limited water in Egypt. So the objective of the present work was evaluated the effect of sowing dates and irrigation regime on water applied, water consumptive use, water use efficiency water saving, crop and, yield for soybean crop.

2. Materials and methods

Two field experiments were carried out for two summer seasons of 2015 and 2016 at Mallawy, Water

Requirements Research Station –El Minia Governorate; Water Management Research Institute- National. Water Research Center. The experiments included four treatments of sowing dates (A) and four regime of irrigation (B) with four replication so that the experiment was arranged in a split plot design. Sowing dates treatments were 10th May, 25th May, 5th June, 20th June. The irrigation regime treatments were traditional irrigation (the farmers practices), 100%, 90%, 80% and 70% of field capacity). Sowing dates were distributed randomly by in the main plots. While irrigation regime treatments were distributed at randomly in the sub- plots. Soybean crop cultivar namely ***(Giza111).*** Each plot contained seven rows or ridges, 60 cm apart and six meters in the length (4.2 x 6m= 25.2 m^2 **)**. All cultural practices were done as recommended for soybean production expiation irrigation regime.

Soil characteristics:

Soil analyses showed that the experimental soil was silt clay loam containing (0.11 and 0.10 % of total N), (11.8 and 11.0 ppm available P), and (0.44 and 0.40 meq/100 g soil K) with pH 8.10, in both studied seasons, respectively. Other agricultural practices required for growing soybean crop were carried out as usually practiced in the region except irrigation treatments. Some physical properties of the experimental soil shown in Table (1).

Table (1): Some physical properties of the experimental soil.

Depth (cm)	Average for two studied		
	Bulk density g/ cm3	Field Capacity	
		%	Cm
0-15	1.19	43.40	7.75
15-30	1.24	37.90	7.05
30-45	1.28	35.15	6.82
45-60	1.41	32.35	6.84
Average	1.28	37.20	28.57

Bulk density was determined by using the undistributed core samples according to Kluke (1986).
Field capacity (F.c%) was determined by field method according to (Black 1965).

Climatic conditions:

Some metrological data during the two growing seasons are presented in Table (2).

These data were obtained from metrological Mallawy Station located at the ˚27° 9˘ latitude and 30° 5˘ longitude and its altitude is about 44m above sea levels.

Data collection

Water Applied

In both growing seasons, water was measured by using a rectangular sharp crested weir. The discharge was calculated using the following formula:

$Q = CLH^{3/2}$ (Masoud, 1967)

Where:

Q: Discharge in cubic meters per second.

L: Length of the crest in meters.

H: Head in meters.

C: An empirical coefficient that must be determined from discharge measurements.

Water applied was added by weir meter during every irrigation for plots of different treatments by taken soil samples before irrigation to determine the moisture content than water applied added until the moisture percentage of different treatments reached 100, 90, 80 and 70 % of field capacity. On the other hand, the farmers usually added irrigation water over field capacity and this lead to low irrigation efficiency and high loss of irrigation water. The quantity of water was measured in studied area (the farmer practices) by cut throat Flume size (20 x 90 cm) where applied water was added during each irrigation and at the end of each growth season the total quantity of water applied was estimated (m^3/ fed.).

Water consumptive use (CU):

Gravimetric soil samples on 20 cm. intervals down to 60 cm, were taken at sowing before and 48 hours after irrigation and at harvesting to determined water consumptive use of soybean crop. Water depth of irrigation and water consumptive use were calculated according to the equations (1) and (2) given by **Isrealsen and Hansen (1962) as follows:**

$Diwa = D \times Bd \times (F.C - Q_1)/100$ …………………. (1).

$CU = D \times Bd \times (Q_2 - Q_1)/100$ …………………. (2).

Where:

Diwa = Depth of irrigation water applied (cm).

Cu = Water consumptive use (cm).

D: Depth of soil layer = 20cm.

Bd: Bulk density gm/cm^3

F.C: Field capacity %

Q_1: Soil moisture % before next irrigation.

Q_2: Soil moisture % 48 hours after irrigation.

Crop water use efficiency (C.W.U.E)

The crop water use efficiency is the weight of marketable crop produced per unit volume of water consumed by plants or the evapotranspition quantity. It was computed for the different treatments by dividing the yield (kg / fed) on units of evapotranspiration expressed as cubic meters of water per fed. (**Abd El- Rasool et al. 1971**) It was calculated by the following formula.

$$C.W.U.E = \frac{\text{Yield (kg / fed.)}}{\text{Water consumptive use (m}^3\text{ / fed.)}} = (\text{kg/ m}^3)$$

Field water use efficiency (F.W.U.E.)

Field water use efficiency is the weight of marketable crop produced per the volume unit of applied irrigation which was expressed as cubic meters of water (**Michael**, 1978).

It was calculated by the following equation:

$$F.W.U.E. = \frac{\text{Yield (kg/fed.)}}{\text{Water applied (m}^3\text{/fed.)}} = (\text{kg/ m}^3)$$

Statistical analysis:

Data obtained from experimental treatments were subjected to statistical analysis and treatments means were compared using the L.S.D methods according to **Snedecor and Cocharn (1980).**

3. Result and Discussion:

Total yield (ton/ fed.):

Data given in Table (3) show that, irrigation regime significantly affected this character in the two studied seasons. Where the highest yield (ton / fed.) was obtaining with sowing soybean at 10th May (1.673 ton / fed.). The highest seed yield may be due to the considerable increases in plant height, number of pods and seeds / plant, and seed weight / plant, and lower insects incidence and disease this due to more favorable weather during this period under El-Minia conditions.

On the contrary, minimum of total yield of soybean crop were obtained by sowing at 25th June (0.943 ton/fed) in the two studied seasons may be due to height temperature and short day length that induce early flowering and termination of the main axis, reduce pod development and in turn seed yield **(Moore et al 1991 and Ali 1993)**. These results are similar to those findings by **Shams El- Din et al (1997), Elsa el al, (1998) and Hassan el al (2002)**. Regarding the irrigation regime effect on this character, data in Table (3) show that the highest mean was obtained from plants which irrigated until 80% field capacity (1.407 ton / feddan) while lowest values of total yield were obtained from conventional irrigation by the farmers practices (1.243 ton in both seasons). These results are similar to those findings by **Uklein (1961), Khvan (1971) and Campbell & Phone (1977)** but were disagree with. **Cure et al. (1983)**, **Ramseur et al. (1984)** and **Cox and Jolliff (1986)** Concerning the interactions between the two studied factors, date in Table (3) show that the highest values were obtained from plants which sowing at 10th May and irrigated until 80% of field capacity (1.760 ton / fed.). This treatment was most superior treatments on this character in the two study studied seasons.

Table (2): The average of temperature, relative humidity %, wind speed (km / day), sun shine (hours /day) and evaporation (mm/day) during the two seasons study for Soybean crop.

Month	Temperature (C)			Relative humidity (%)			Sun shine (hour/day)	Wind speed		Evaporation (mm/day)
	Maximum	Minimum	Average	Maximum	Minimum	Average		m/s	kg/day	
May	34.70	17.12	25.91	85.87	17.35	51.16	11.93	4.28	369.79	10.31
June	34.69	19.96	31.46	86.47	20.9	53.69	12.22	4.74	409.54	12.17
July	36.70	20.99	28.85	93.65	23.16	58.41	12.65	4.01	246.46	11.40
October	37.21	22.59	29.9	97.63	29.03	63.33	11.66	3.41	294.62	10.61
September	36.09	20.4	28.07	96.84	27.13	61.99	10.12	3.25	280.8	7.87
October	31.36	16.81	24.08	99.92	28.00	63.96	9.81	2.94	254.02	5.73

Table (3): Effect of planting dates and irrigation regime on production of Soybean in summer seasons 2015 and 2016.

Treatments / Planting dates (A)	**Total yield (ton/ fed.) Irrigation regime (b)**				**Mean (A)**
	b_1	**b_2**	**b_3**	**b_4**	
A_1	**1.600**	**1.620**	**1.700**	**1.760**	**1.673**
A_2	**1.420**	**1.450**	**1.485**	**1.629**	**1.496**
A_3	**1.100**	**1.180**	**1.190**	**1.220**	**1.173**
A_4	**0.850**	**0.910**	**0.99**	**1.020**	**0.943**
Mean (B)	**1.243**	**1.293**	**1.341**	**1.407**	
LSD = 5%	A =0.077 *		B = 0.0715* AB=0.142*		

Where: Planting dates (A) Irrigation regime (b) A_1=Planting date at 10th May b_1 = Conventional irrigation.
A_2= Planting date at 25th May (conventional planting) b_2 = irrigation until 100% of field capacity.
A_3 = Planting date at 10th June b_3= irrigation until 90 % of field capacity. A_4 = Planting date at 25th June
b_4= irrigation until 80% of field capacity.

Water applied (m^3/ fed)

The amount of applied water delivered (m^3/fed) to different treatments are shown in Table (4). The results show that different planting dates were significantly affected on this character in both seasons. The amount of applied water delivered (m^3/fed) to different main treatment were 3011.11, 3133.97, 3194.89 and 3283.73 m^3 for A_1, A_2, A_3 and A_4 respectively. It clear from data that there are slight differences in water quantities from the treatment of others due to the different dates of agriculture.

Regarding the irrigation regime data shows that the irrigation regime were significantly affected in two study seasons where, the highest value was obtained from plants which irrigated by conventional irrigation b_1(farmer practices) 3308.14m^3/fed while, the lowest value was obtained from plants irrigated until 80% of field capacity A4 2870.51 m^3/fed.

With regard interaction among the studied factors data in Table (4) show that interaction had significant effect on both seasons. Generally the best treatment from view point of water and production was treatment (A_1b_4) which planting at 10th May with irrigated until 80% of field capacity where gave the highest yield (1.760 ton /fed.) the least amount of water applied (2988.64 m3/fed.).

Water saving (m3/ area):

Data in Table (5) show the average quantity of water saving (m3/ fed.) for the best treatment A_1b_4 (planting date at 10th May and irrigated soybean until 80% of field capacity) when compared to control treatment A_2b_1 (planting date at 25th May and irrigated by conventional irrigation.

The obtained results in present study show that when the best method of water

(A_1b_4) was used the irrigation water is saved more than the control treatment (common method in region) by about 18.96 %. The results show also that, the amount of irrigation water which can be saved (average area cultivated by soybean in El- Minia region) by about 76254000 million m^3/ area compared to conventional irrigation in region. This amount of saving water enough to cultivate area about (generally) 12709 feddan in old lands under El-Minia conditions. Therefore, estimating economic of irrigation water becomes very important for planning irrigation management where the over irrigation by the farmers usually leads to low irrigation efficiency and high loss of water and fertilizers.

Table (4): Average of the quantity of applied of water (monthly and seasonal) m^3/ fed. for soybean crop during 2015 and 2016.

Treatments / Planting dates (A)	Water applied (m3/fed)				Mean (A)
	Irrigation regime (B)				
	b_1	b_2	b_3	b_4	
A_1	3304.9	3117.18	2906.35	2716.01	3011.11
A_2	3351.46	3271.44	3042.83	2870.13	3133.97
A_3	3423.19	3334.29	3114.82	2907.26	3194.89
A_4	3513.01	3434.81	3198.46	2988.64	3283.73
Mean (B)	3398.14	3289.43	3065.62	2870.51	
LSD = 5%	A =20.223* B =18.89* AB= 75.56*				

Source: Actual field measurements

Where; A_1=Planting date on 10th May b_1 = Conventional irrigation by farmer practices.
A_2= Planting date on 25th May (conventional planting) b_2 = irrigation until 100% of field capacity. A_3 = Planting date on 10th June b_3= irrigation until 90 % of field capacity. A_4 = Planting date on 25th June b_4= irrigation until 80% of field capacity.

Table (5): Water saving (m^3/fed) which obtained from the best treatment (A_1b_4) compared to conventional irrigation in the region (A_2b_1) for soybean crop during 2015 and 2016.

Treatment	Total yield (Ton/fed)	Increasing of yield		Water applied m3/fed	Saved water		*Average area cultivated of soybean in El- Minia region - Egypt	The total of water saving millioned/ m3/area	The area (fed,)of old land which can be cultivated as resulting of saving water
		Ton /fed	%		m3/fed	%			
Traditional treatment in the region (A_2b_1)	1.420	0.34	23.94	3351.46	635.45	18.96	120000	76254000	12709
The best treatment from view point water and agriculture (A_1b_4)	1.760			2716.01					

Source: Ministry of Agriculture - Field Crops Research Institute - Aerial Photography 2017.

Monthly actual water consumptive use (cm/ month):

From the data of actual consumptive use by the soil moisture depletion method, for soybean crop is shown in Tables (6). It could be noticed that monthly actual water consumptive use starts with small amount because small of little water needs of plants at initial growth stage, therefore, soil moisture are mainly affect by evaporation from soil surface at this time, with the advance with plant age, evapotranspiration increases and consequently the monthly consumptive use increased as plant foliage develops.

The monthly water consumptive use reaches its peak value in the middle of growing season (pods formation), which is considered the critical period in water demands of crops. Data in Table (6) reveal that the maximum monthly consumptive use was 15.93 cm / monthly during July for A_1 while was 19.26, 20.27 and 19.71 cm/ monthly during August for A_2,A_3 and A_4 respectively under all sub treatments in the two studied season

Seasonal actual consumptive use (cm/season)

Seasonal water consumptive use (cm/ season) are presented in Table (7). The results show that planting dates significant effect this character in both seasons where the values of actual water consumptive use different from treatment to other which due to different planting dates. The results show that the mean values of seasonal water consumptive use were 51.48, 48.1, 55.15 and 56.12 cm/ season for A_1,A_2,A_3 and A_4 respectively. Also it is clear from the date in Table (7) irrigation regime affected significantly in the two studied seasons. The highest value was (56.77 cm / season) obtained from plants which irrigated with conventional irrigation (farmer practices) while, the lowest value was (51.53 cm/ season) obtained from plants which irrigated until 80% of field capacity this is due to a decrease in the amount of water applied which led to reducing the amount of water consumed for this treatment.

With regard to the interactions between the studied factors, data in Table (7) show that interactions was significant affected in the two studied season. However, the highest value was obtained from plants which sowing in late date on 25th July (A_4b_1) which irrigated by conventional irrigation (58.51 cm/season) but the lowest value obtained from plants which sowing in early date on 10th May (A_1b_4) which irrigated until 80% of field capacity (46.86cm/season).

Table (6): Average values of monthly water consumptive use (cm/month) for soybean plants as affected by sowing dates and irrigation regime in both studied seasons.

Month	Temperature (C)			Relative humidity (%)			Sun shine (hour/day)	Wind speed		Evaporation (mm/day)
	Maximum	Minimum	Average	Maximum	Minimum	Average		m/s	kg/day	
May	34.70	17.12	25.91	85.87	17.35	51.16	11.93	4.28	369.79	10.31
June	34.69	19.96	31.46	86.47	20.9	53.69	12.22	4.74	409.54	12.17
July	36.70	20.99	28.85	93.65	23.16	58.41	12.65	4.01	246.46	11.40
October	37.21	22.59	29.9	97.63	29.03	63.33	11.66	3.41	294.62	10.61
September	36.09	20.4	28.07	96.84	27.13	61.99	10.12	3.25	280.8	7.87
October	31.36	16.81	24.08	99.92	28.00	63.96	9.81	2.94	254.02	5.73

Table (7): Average values of seasonal water consumptive use (cm/seasons) for soybean plants as affected by sowing dates and irrigation regime in both studied seasons.

Treatments / Planting dates (A)	Water applied (m3/fed) Irrigation regime (b)				Mean (A)
	b_1	b_2	b_3	b_4	
A1	55.1	53.72	50.26	46.86	51.48
A2	56.23	54.99	53.48	51.72	54.1
A3	57.27	55.89	54.7	52.83	55.15
A4	58.51	56.75	55.31	53.91	56.12
Mean (B)	56.77	55.34	53.43	51.33	
LSD = 5%	A =0.345 * B =0.615 * AB= 1.238 *				

Source: Actual field measurements

Where; Planting dates (A) Irrigation regime (b) A_1=Planting date at 10th May b_1 = Conventional irrigation by farmer practices. A_2= Planting date at 25th May (conventional planting) b_2 = irrigation until 100% of field capacity. A_3 = Planting date at 10th June b_3= irrigation until 90 % of field capacity. A_4 = Planting date at 25th June b_4= irrigation until 80% of field capacity.

Water use efficiency (WUE):

The water use efficiency is obtained by evaluating the two parameters of total yield per unit of water applied and water consumptive use. Water use efficiency is a tool for maximizing crop production per each unit of irrigation water. Effect of the different planting dates and irrigation regime on water use efficiency (field and crop water use efficiency) are presented in Table (8). The obtained results show that the sowing dates were significantly affect on water use efficiency. Where the highest values of field and crop water use efficiency (0.56 and 0.77 kg/m^3) were obtained from plants which sowing date at (10th May A_1) respectively while, the lowest values of field and crop water use efficiency (0.29 and 0.45 kg/ m^3) respectively were obtained from plants which sowing date at (25th June A_4) in the two studied seasons. Also results indicated that water use efficiency was increased with increasing water stress where, the highest values of field and crop water use efficiency (0.50 and 0.60 kg/m^3) were obtained from plants which irrigated until 80% of field capacity (b_4) respectively in both seasons. With regard to the interactions among the studies factor data in Table (8) show that the interactions significantly affected in both seasons where, the highest values of field and crop water use efficiencies (0.65 kg/m3 and 0.89 kg/m^3) were obtained from treatment A_1b_4 respectively. This is mainly due to the higher yield of soybean crop and decrease water applied and water consumptive use for this treatment. While, the lowest value of field and crop water use efficiencies (0.24 and 0.35 kg/m^3 respectively) were obtained from treatments A_4b_1. These results indicate that irrigation soybean crop until 80% of field capacity and planting on 10th May is the best treatment from the view point of water management for soybean yield.

Table (8): Values of total field and crop water use efficiencies (kg/m3) for soybean crop in both studied seasons.

Treatments / Planting dates (A)	Field water use efficiency (FWUE)				Mean (A)	Crop water use efficiency (CWUE)				Mean (A)
	Irrigation regime (b)					Irrigation regime (b)				
	b_1	b_2	b_3	b_4		b_1	b_2	b_3	b_4	
A_1	0.48	0.52	0.59	0.65	0.56	0.69	0.72	0.81	0.89	0.77
A_2	0.42	0.44	0.49	0.57	0.48	0.60	0.63	0.66	0.75	0.66
A_3	0.32	0.35	0.38	0.42	0.37	0.46	0.50	0.52	0.55	0.51
A_4	0.24	0.26	0.31	0.34	0.29	0.35	0.38	0.43	0.45	0.40
Mean (B)	0.37	0.39	0.44	0.50		0.53	0.56	0.61	0.66	
L.S.D 5%	A B AB 0. 03* 0.02* 0.08*					A B AB 0.03* 0.08* 0.08*				

Source: Actual field measurements

Where; Planting dates (A) Irrigation regime (b) A_1=Planting date at 10th May b_1 = Conventional irrigation by farmer practices. A_2= Planting date at 25th May (conventional planting) b_2 = irrigation until 100% of field capacity. A_3 = Planting date at 10th June b_3= irrigation until 90 % of field capacity. A_4 = Planting date at 25th June b_4= irrigation until 80% of field capacity.

4. Conclusion

Considering the previous discussion results indicate that treatment A_1b_4 (planting soybean on 10th May with irrigate until 80% of field capacity) was the best treatment (from view point of water and economic) it lead to increase in productivity with rate equal 23.94% and water saving about by 18.96% compare with the traditional method in this region. Also the highest values of net return of each irrigation water (kg / m3) and financial benefits (L.E/ area) were gained with it. At the end of this study the obtained results indicate that it may be recommended by planting soybean on 10th May with irrigate until 80% of field capacity to produce the highest yield with less amount of water, under El-Minia Region conditions.

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