RESPONSE OF GREEN BEAN TO PULSE SUBSURFACE TRICKLE IRRIGATION

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ABSTRACT

The effect of pulse irrigation system on yield and nutritional elements of green beans, (Phaselous vulgaris L.) irrigated with subsurface trickle irrigation system under field conditions in the Mediterranean region of Egypt were evaluated along two years. The irrigation system consisted of four irrigation treatments based on the number of pulses which ranged from T1 where the irrigation water requirement was applied at one time to T4 where the irrigation water requirement was applied using four pulses. The number of pulses per each irrigation significantly affected the green bean vegetative growth and yields. Maximum and minimum yields were obtained from T4 and T1 treatments as 24,307.73 and 17516.80 kg/ha in the first experimental year 2008, and 24,085.60 and 17326.40 kg/ha in the second experimental year 2009, respectively. Seasonal water use values varied from 382 mm in experimental year of 2008 to 390 mm in experimental year of 2009. Water use efficiency (WUE) and irrigation water use efficiency (IWUE) values were significantly influenced by the number of pulses per each irrigation. WUE ranged from 4.59 kg m^{-3} in T1 to 6.84 kg m^{-3} in T4 for the first experimental year, and varied from 4.44 kg m^{-3} in T1 to 6.64 kg m^{-3} in T4 in the second experimental year. It was found that the highest concentration of all determined nutrient elements was obtained in the high pulse irrigation T4. While, the lowest concentration was obtained in the low pulse irrigation T1.

INTRODUCTION

Water is becoming increasingly scarce, creating droughts which are becoming more serious due to changing climate conditions, especially in the Mediterranean region, where Egypt is located in arid region. Thus, water supply is a major constraint to crop production in the Mediterranean region of Egypt.

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The economy of the region relies heavily on irrigated crop production. However, surface irrigation is commonly used in the area resulting in low irrigation efficiencies as well as salinity and drainage problems. Efficient use of irrigation water is becoming increasingly important, and alternative water application methods such as trickle and low pressure sprinkler, may contribute substantially to making the best use of water for agriculture and improving irrigation efficiency.

The trend in recent years has been towards conversion of surface to trickle irrigation which is considered to be a more efficient delivery system. Scheduling water application is very critical in making the most efficient use of trickle irrigation system, as excessive irrigation reduces yield, while inadequate irrigation causes water stress and reduces production. On the other hand, the intensity of the operation requires that the soil water supply be kept at the optimal level to maximize returns to the farmer. High-frequency water management by trickle irrigation minimizes soil as a storage reservoir for water, provides at least the daily requirements of water to a portion of the root zone of each plant, and maintains a high soil matric potential in the rhizosphere to reduce plant water stress **(Phene and Sanders, 1976; Nakayama and Bucks, 1986)**.

World green bean ***(Phaselous vulgaris L.)*** production is 4,310,733 metric tones, and Egypt is ranked the sixth one with the production level of 215,000 tones **(FAOSTAT, 2007)**.

Water management in green bean production is extremely important at all stages of plant development due to its influence on stand establishment, pod set and quality. For this reason, the crop must be supplied with adequate water to ensure vigorous growth. Irrigation is important for its plant and pod growth **(Smesrud et al., 1997)**.

One of the most common irrigation methods practiced for green bean production in Egypt is furrow irrigation system, whereby the farmers over irrigate, resulting in high water losses and low irrigation efficiencies. With trickle irrigation systems, water and nutrients can be applied directly to the crop at the root level, having positive effects on yield and water saving **(Phene and Howell, 1984; Bozkurt et al., 2006)**.

For these reasons, trickle irrigation systems have witnessed widespread use in the world in recent years.

In a lysimeter study in Bari, Italy, **Tarantino and Rubino (1989)** estimated the seasonal irrigation water requirement and water use as 235 and 276 mm, respectively.

The dependence of crop yields on water supply is a critical issue because of the increasingly limited water resources for irrigation. Irrigation intervals and plant–pan coefficients had significant effect on yield and quality of green bean **(Sezen, et al., 2008)**. Irrigation scheduling based on a 0.8 crop-pan coefficient is recommended for conventional SDI, with 1.0, being more appropriate for partial root zone-drying practice by green bean producers experiencing water shortage **(Cafer Gencoglan *et al.*, 2006)**.

Pulsing irrigation refers to the practice of irrigating for a short period then waiting for another short period, and repeating this on-off cycle until the entire irrigation water is applied **(Eric *et al.*, 2004)**. Applying irrigation water in stages or pulses rather than all at one time can save water by giving the media time to moisten from the first pulse of water thereby allowing it to absorb subsequent irrigation more readily and reducing the total amount of water required **(Scott, 2000)**. Pulse irrigation raises the main part of the root zone closer to the soil surface. Since the root zone is closer to the soil surface, it is closer to the atmospheric oxygen and soil temperatures will increase more quickly in spring than in the lower parts of the soil. Pulse irrigation has a promising potential and it needs to be further investigated. If pulse irrigation is conducted incorrectly it can lead to water logging and crop loss **(Goodwin, 2005)**.

The size of the wetted zone can be increased if irrigation is pulsed **(Eric *et al.*, 2004)**. The results of this study showed a consistent trend that pulsing irrigation reduce the vapor pressure deficit about the trees. As increasing vapor pressure deficit can increase the plants internal water deficits. It can be assumed that the pulsing irrigation system was effective in reducing water stress within the tree **(Bouma *et al.*, 2003)**.

Several experiments have shown positive responses in some crops to high pulse trickle irrigation **(Freeman *et al.*, 1976; Segal *et al.*, 2000; Sharmasarkar *et al.*, 2001)**.The advantages of pulsing are that plant growth is generally greater than with standard irrigation and lower fertilizer rates can be used **(Dole, 1994)**.

Water and nutrients acquisition by plants, and the formation of a depleted zone in the immediate vicinity of the roots are the driving forces for solute movement towards the roots. Nutrient transport from the soil solution to root surface takes place by two simultaneous processes: convection in the water flow (mass Flow) and diffusion along the concentration gradient **(Barber, 1995, Junk, 1996)**. Soil properties, crop characteristics and growing conditions affect the relative importance of each mechanism, but the general situation is that the mobile NO_3 ion supply is taken up mainly through mass flow, while for less mobile elements such as P and K, diffusion is the governing mechanism **(Mmolawa and Or 2000)**.

The nutrient concentrations in the rhizosphere may be high or even excessive immediately after irrigation and may fall to deficit levels as time proceeds **(Xu et al., 2004)**. Reducing the time interval between successive irrigations in order to maintain constant, optimal water content in the root zone may reduce the variations in nutrient concentration, thereby increasing their availability to plants **(Silber et al., 2003)**.

The objectives of this study are to: (i) determine the effect of pulse irrigation on yield and nutrimental elements of field grown green bean irrigated by a subsurface trickle irrigation system and (ii) evaluate the water use efficiency of green bean in the Mediterranean region of Egypt.

MATERIALS AND METHODS

Two field experiments were conducted during the growing seasons 2008 and 2009, between the months of March and June, on the experimental field of Agriculture Engineering Department, situated in El-Giza, Egypt, latitude 30.0861N, and longitude 31.2122E, and mean altitude 17 m above sea level.

The experimental area has an arid climate with cool winters and hot dry summers prevailing in the experimental area. Table 1 summarizes the monthly mean climatic data for the two seasons 2008 and 2009 respectively for El-Giza governorate which are nearly the same. The data of maximum and minimum temperature, relative humidity and wind speed were obtained from "The Central Laboratory of Meteorology" which related to Ministry of Agriculture. There wasn't rainfall can be take in to consideration through the two seasons; because the amount was very small and the duration wasn't exceed a few minutes and it happens just one time, this is because we has an arid climate.

Table (1): Some monthly and growing season climatic data of the experimental area

Months	Mean temperatures (°C)						Relative humidity (%)	
	Minimum		Maximum		Average			
	2008	2009	2008	2009	2008	2009	2008	2009
March	14.8	15.1	26.5	26.9	20.6	21.0	49.4	49.7
April	15.8	16.0	28.5	28.7	22.2	22.3	49.4	50.0
May	15.8	16.1	28.5	29.8	22.2	23.0	49.4	49.8
June	18.5	18.7	31.2	31.3	24.9	25.0	46.5	48.6

The soil of experimental site is classified as sandy clay loam. The available soil moisture content of the experimental site was estimated to be 152.66 mm in a 60 cm soil profile. Some physical and chemical properties of the experimental soil are displayed in Table 2. Irrigation water was obtained from a deep well in the experimental area, with pH 7.2, and an average electrical conductivity of 0.83 dS m^{-1}. Organic matter percent was 19 g kg^{-1} determined by oxidizing with chromic acid according to **Walkley and Black (1934)** and calcium carbonate percent was 29 g kg^{-1} estimated using Collins calcimeter according to **Wright (1939)**.

The experimental field was planted by hand at 70 cm row spacing at 5 cm soil depth. Polista green bean cultivar was planted on 15 March 2009. Plants were thinned to an approximate spacing of 5 - 7 cm in the rows when the plants were about 15 cm in height. A common recommended fertilization practice in the area was followed in the study. All treatment plots received the same amount of total fertilizer. The experimental design was split plots with three replications. Each plot was 10 m long and 6 plant rows wide (4.2 m).

Table(2): Some physical and chemical properties of experimental soil

Soil depth (cm)	Texture	FC (cm^3cm^{-3})	PWP (cm^3cm^{-3})	Bulk density ($g\ cm^{-3}$)	pH	EC_e ($dS\ m^{-1}$)
0 – 20	SCL	42.07	14.43	1.29	7.74	2.43
20 – 40	SCL	41.80	14.91	1.31	7.69	1.92
40 - 60	SCL	38.96	17.15	1.33	7.81	1.78

A commercial compound fertilizer of (N–P–K ratio 18–46–0) was applied at a rate of 50 kg N and 120 kg P_2O_5, as pure matter per hectare at planting on both years. The rest of the N was applied to the experimental plots in the form of ammonium nitrate (33% N) at a rate of 45 kg ha^{-1} on 10 May 2008 in the first and on 13 May 2009 in the second experimental year. In addition, zinc (Zn) at a rate of 4.5 kg ha^{-1} and 20 L ha^{-1} of phosphoric acid were applied on the same dates. The latter was applied for prevention of emitter clogging.

A subsurface trickle irrigation system was designed for the experiment. Laterals were laid for each plant row at 15 cm depth, and inline emitters with discharge rate of 13.34 L/h for meter length, the emitters were spaced at 30 cm intervals on the lateral line. The system was operated at 100 kPa throughout the growing season. The control unit of the system consisted of a pump, gravel and disk filters, a flow meter, control valves, fertilizer tank, and pressure gauges.

Four treatments of pulse irrigation were applied T1 through T4. T1 is the control where the irrigation water requirement was applied at one time, T2 where the irrigation water requirement was applied at two times till T4 where the irrigation water requirement was applied at four times per irrigation. The time between pulses was 1 hour between each pulse and it was determined according to the redistribution of water in the soil which depends mainly on the unsaturated hydraulic conductivity and the root water uptake. The irrigation water applied was calculated through CropWat software and the on/off time was managed by using solenoid valve.

Soil water content was measured at 20 cm increments down to 60 cm, using a profile probe before irrigations throughout the growing season. The access tubes were installed in the crop rows at the center of the experimental plots. The profile probe was calibrated against the soil water content, determined by gravimetric sampling. Surface soil layer (0–20cm) was sampled gravimetrically.

Green bean plants were harvested and weighed four times for individual plots ($42m^2$) representing each treatment. Yield was determined by hand harvesting the 6 m sections of the three adjacent center rows in each plot. The harvest area in each plot was 12.6 m^2 (three rows, each 6 m long). Total green bean mass was determined for each irrigation treatment. At the last harvest date, five bean plants were cut at the soil surface, and then stems and leaves were separated to determine plant dry weight for each irrigation treatment. Plant-samples were dried in the oven at 70 $^{\circ}C$ until constant weight was reached. Mean plant dry weights were determined from an average of five plants. Ground plant material was digested with sulphoric acid as reported by **Yoshida et al., (1976)** and analyzed for N, P and K. Nitrogen determination applying the Kjeldahl method. P was determined by molybdenum blue colorimetric described by **Jakson (1973)**. K was determined by flame photometer according to **Jakson (1973)**. The chlorophyll was measured by using "Minolta Chlorophyll Meter", SPAD-502 (Spectrum Technologies).

Water-use efficiency (WUE) and irrigation water-use efficiency (IWUE) values were calculated as fresh green bean yield divided by seasonal ET and total seasonal irrigation water applied, respectively **(Tanner and Sinclair, 1983; Howell et al., 1990).**

RESULTS AND DISCUSSION

Green bean yields, irrigation amounts, water use and water use efficiency (WUE) data are summarized in Table 3. Pulse irrigation had significantly affected green bean yields. The highest yield average 24,307.73 kg ha^{-1}

was obtained in T4 treatment, followed by T3 and T2 with 21,293.07 and 19,040 kg ha^{-1} in 2008. The minimum yield was obtained from the T1 treatment as 17516.80 kg ha^{-1} for the first experimental year. In 2009, similar to the previous year, the maximum yield was obtained from the T4 treatment 24,085.60 kg ha^{-1} and followed by T3 and T2 with yields of 21,039.2kg ha^{-1} versus 18,659.20 kg ha^{-1}, respectively. The minimum yield as in the first year was obtained from the T1 treatment with 17,326.40 kg ha^{-1} for the second experimental year. These results are in line with those obtained by **Sezen et al. (2008)**. They reported that pulse irrigation had significant effect on yields of field grown green bean under the Mediterranean climatic conditions. The maximum yield was obtained from the treatment which had the highest water use. Previous studies demonstrated that increasing fertigation frequency significantly increased plant yield, especially at low nutrient concentrations **(Xu et al., 2004)**, and that the yield improvement was primarily related to increased P uptake **(Silber et al., 2005)**.

Table (3): Yield, irrigation, water use, water use efficiency (WUE) and irrigation water use efficiency (IWUE) data of green bean under four treatments and two growing seasons.

Treatment	Experimental Years	Seasonal irrigation (mm)	Water Use (mm)	Yield (kg ha^{-1})	WUE (Yield/Seasonal Irrigation) (kg m^{-3})	IWUE (Yield/Water Use) (kg m^{-3})
T1 (1 Pulse)	2008	382.00	400.00	17517	4.59	4.38
T2 (2 Pulses)		374.36	392.00	19040	5.09	4.86
T3 (3 Pulses)		362.90	380.00	21293	5.87	5.60
T4 (4 Pulses)		355.26	372.00	24308	6.84	6.53
T1 (1 Pulse)	2009	390.00	408.00	17326	4.44	4.25
T2 (2 Pulses)		382.20	402.55	18659	4.88	4.64
T3 (3 Pulses)		370.50	394.25	21039	5.68	5.34
T4 (4 Pulses)		362.70	385.95	24086	6.64	6.24

Seasonal water used by green bean varied from 382 mm for T1 to 355.26 mm for T4 in the first year (2008) to 390 mm for T1 to to 362.70 mm for

T4 in the second year (2009). In both experimental years, water use values decreased with increasing number of pulses in each irrigation.

The highest WUE 6.84 kg m^{-3} was obtained in T4 treatment in the first year and the minimum WUE was observed in T1 treatment in the second year. In general, WUE values decreased with decreasing number of pulses. IWUE values varied from a minimum of 4.38 kg m^{-3} in T1 treatment to a maximum of 6.53 kg m^{-3} in T4 treatment in the first year; and green bean response to pulse irrigation applied with subsurface trickle system indicated that the higher the number of pulses, the higher the yield of green bean in each irrigation.

The effect of the pulse irrigation treatments on vegetative growth is presented in Table 4. Treatment four (T4) produced the highest plant height followed by treatment three (T3) then treatment two (T2). The lowest value was recorded in treatment one (T1). Moreover, the difference between T3 and T4 was not significant. This trend was similar in both seasons under study. This result was in accordance with **Son and Oh (2003)**. They indicated that continuous and high pulse irrigation (four times per irrigation) enhanced a more stable water content, and increased growth and plant height compared with the case where plants were irrigated once a day.

The number of leaves was significantly affected by treatments. The highest value was observed in T4 followed by T3; the lowest values were recorded in T2 and T1. No significant difference was found between T2 and T1.

Significant differences in plant fresh weight were found among treatments (Table 4). The best value was observed in T4 followed by T3; although T2 was higher than T1, but the difference between them was not significant. **Assouline et al. (2006)** reported that high pulse irrigation with freshwater had led to an increase in plant weight, as compared with the once daily irrigation.

Table (4): Effect of pulse irrigation on vegetative growth parameters of Polista snap bean cultivar during 2008 and 2009 seasons.

Treatment	**Experimental Years**	**Plant height (cm)**	**N. of leaves**	**fresh weight of pod (g)**	**Dry weight of pod (g)**	**leaf area (cm^2)**	**chlorophyll**
T1 (1 Pulse)	2008	28.33	5.33	15.33	2.60	108.43	37.66
T2 (2 Pulses)		34.75	5.25	18	3.35	144.70	38.35
T3 (3 Pulses)		39.67	7.67	28.33	4.07	156.53	38.46
T4 (4 Pulses)		44	10.33	43	6.67	164.33	42.96
T1 (1 Pulse)	2009	31.00	5.33	16	2.57	113.97	39.77
T2 (2 Pulses)		36.00	5.67	20.67	3.40	150.67	37.40
T3 (3 Pulses)		43.34	7.33	28.67	4.30	165.87	39.30
T4 (4 Pulses)		44	9.67	43.67	6.87	176.73	45.53

There is a proportional relation between increasing pulse irrigation and dry weight. The highest dry weight was reported in T4. There was no significant difference either between T3 and T2 or between T2 and T1. The significant effect of the frequent irrigation treatments on the dry weight may be attributed to improved phosphorus mobilization and uptake **(Silber et al., 2005)**.

By increasing the number of pulses per irrigation, the leaf area increases. The superior value was recorded in T4 followed by T3. T3 had a higher value than T2, but the difference was not significant. Also, T2 had higher value than T1, however the difference was not significant. This result is in accordance with **Assouline et al. (2006)** who found that frequent irrigation had little positive effect on leaf area in the first stage of growth. Chlorophyll content had the highest significant value in T4. There were insignificant differences among T3, T2 and T1.

There were significant differences in the nitrogen, phosphorus and potassium concentration of shoots and pods among the studied irrigation systems during both seasons of study (Table 5). In this regard, the highest concentration of all determined macro-elements was obtained in case of T4 followed by T3 and T2. Obtained results are in agreement with

Silber et al., (2005) who reported significant advantages of high pulse irrigation at very low P rate. High pulse irrigation showed positive effects on the concentration of N, P in leaves **(Assouline et. Al., 2006)**.

Table (5): The N, P and K concentration for each treatment for both growing seasons in pods and shoots.

Treatments	Experimental Years	N ($g\ kg^{-1}$) DW		P ($g\ kg^{-1}$) DW		K ($g\ kg^{-1}$) DW	
		shoot	pod	shoot	pod	shoot	pod
T1 (1 Pulse)	2008	18.61	22.21	4.43	4.86	19.80	27.31
T2 (2 Pulses)		18.91	22.59	4.75	5.22	20.86	28.85
T3 (3 Pulses)		19.11	22.76	5.02	5.52	21.70	29.81
T4 (4 Pulses)		19.21	22.95	5.25	5.79	22.59	30.88
T1 (1 Pulse)	2009	18.63	22.24	4.44	4.88	19.81	27.33
T2 (2 Pulses)		18.95	22.61	4.76	5.25	20.88	28.89
T3 (3 Pulses)		19.14	22.79	5.01	5.54	21.74	29.84
T4 (4 Pulses)		19.23	22.99	5.00	5.80	21.87	33.15

The highest percentage of the determined macro-elements was obtained under treatment T4. Higher pulse irrigation may be attributed to the abundance of water at the root zone which reduce the viscosity of water solution which consequently increased the movement and absorption of such macro-elements from the soil by plants. Similar results were reported by **Rodriguez Perez (1987)** on bean. On the other hand T1 reflected the lowest concentration of all determined macro-elements in shoots and pods during both seasons of the experiment.

The lower pulse irrigation was connected with the effect of this method on decreasing the vegetative growth of plant and the chemical composition of shoots which consequently affect the chemical composition of produced pods. Obtained results are in agreement with those reported by **Gawish, (1992)**. In the interval between two subsequent irrigation events, the water content, and consequently, the soil unsaturated hydraulic conductivity decrease **(Da Silva, 1991)**, resulting in a decrease in nutrient availability **(Junk, 1996)** and an increase of solutes concentrations in the vicinity of the roots, both of which negatively affect plant growth. Therefore lowering the application rate to match plant water uptake rate as closely as possible improve irrigation efficiency **(Batchelor et al., 1996).**

The differences in the concentrations of the nutrients takes up may be due to their solubility and the amount available. P is relatively insoluble compared to N and K and higher doses of N and K than P were applied on all the soils, which is reflected in the concentrations.

Statistical analysis of green bean vegetative and nutrients parameters (Table 6) indicated that pulse irrigation had highly significant different effects on values between each treatment. On the other hand there was no significant difference between both growing seasons.

In both experimental years, green bean yields decreased significantly as the number of pulses decreased. The T4 treatment resulted in the highest yield in both experimental years. Therefore it is recommended to apply irrigation water requirement at four times. Seasonal irrigation water requirement of green bean for the recommended treatment was 382 and 390 mm for the experimental years, respectively. **Silim and Saxena (1993)** reported seasonal irrigation water requirement for trickle-irrigated green bean in Syria as 439 mm; and **Borosic et al. (2000)** determined water requirement of green bean as 400 mm in Zagreb. Since the rainfall received during the growing season was not significant, the crop water consumption practically depended only on the amount of the irrigation water supplied to the treatments.

In both experimental years, WUE and IWUE values decreased with decreasing number of pulses. **Stansel and Smittle (1980)** reported green bean WUE value of 4–6 kg m^{-3} in GA, USA. **Bryla et al. (2003)** estimated a WUE of 1.6 kg m^{-3} and IWUE of 1.9 kg m^{-3} for subsurface trickle-irrigated green bean; **Barros and Hanks (1993)** reported WUE of 3.62 kg m^{-3} for green bean, **Singh et al. (2000)** determined a WUE value of 2.3 and 3.0 kg m^{-3}, for irrigated and non-irrigated green bean in a lysimeter study. WUE and IWUE values determined in this study were generally higher than the those ones reported in the literature.

Soil water in the 60 cm soil depth in all treatments remained above 60% of available water throughout the growing season. Green bean is most sensitive to moisture stress during flowering and pod sizing. **Stock and El-Naggar (1980)** concluded that the optimum soil water content during flowering should be at 40–60% of the available water and that either higher or lower water content resulted in suboptimal seed yields.

Soil water potential in the vicinity of active roots generally controls the rate of water and nutrient uptake by plants. The result of soil water partitioning and solute mixing the creation of nutrient uptake response to fluctuations in soil-water content that is distinct from the response expected if the soil-water content is constant. Thus, uptake of diffusion-limited nutrients should increase as the frequency of changes in water content increases.

CONCLUSIONS

In this study, our results demonstrated that the pulse irrigation had significant effect on yields of field grown green bean under the Mediterranean climatic conditions in Egypt. The number of pulses per each irrigation had significant effect on yield and nutrients concentration in the soil. The maximum yield of 24308 kg ha^{-1} was obtained from T4 treatment in 2008 and 24086 kg ha^{-1} in 2009. Moreover, T4 treatment resulted in better quality than as compared to other treatments. The results indicated that WUE and IWUE values decreased with the decreasing number of pulses per each irrigation. Thus, it is recommended to apply irrigation water at three or four times. In conclusion, T4 treatment is recommended for subsurface trickle-irrigated green bean grown under field conditions in order to save water by giving the media time to moisten from the first pulse of water thereby allowing it to absorb subsequent irrigation more readily and reducing the total amount of water required and to obtain higher and better quality yield in the Mediterranean region of Egypt. The higher pulse irrigation may reduce the variations in nutrients concentration, thereby increasing their availability to plants. We hypothesized that by applying pulse irrigation and nutrients at the rates that the plant requires, we would be able to reduce the quantities of fertilizer needed to achieve optimal production.

Table (6): Statistical analysis

The interaction of Treatment X Seasons		Parameters											
		Plant Height	N. in Leaves	Fresh Weight	Dry weight	Leaf Area	Chlorophyll	N		P		K	
								Shoot	Pod	Shoot	Pod	Shoot	Pod
First Season	T1	28.34 e	5.333 c	15.34 c	2.600 c	108.433 e	37.667 c	18.610 c	22.21 d	4.430 d	4.860 d	19.80 d	27.31 c
	T2	34.75 cd	5.250 c	18.00 c	3.350 bc	144.775 c	38.350 c	18.91 b	22.59 c	4.750 c	5.220 c	20.86 c	28.85 bc
	T3	39.67 ab	7.667 b	28.333 b	4.067 b	156.53 bc	38.467 c	19.11 ab	22.76 b	5.020 b	5.520 b	21.70 b	29.81 bc
	T4	44.00 a	10.333 a	43.000 a	6.667 a	164.34 ab	42.967 b	19.21 b	22.95 a	5.250 a	5.790 a	22.59 a	30.88 ab
	Seasons	36.69 b	7.146	26.167	4.171	143.519 a	39.363	18.897	22.63	4.862	5.347	21.24 a	29.212
Second Season	T1	31.00 de	5.333 c	16.00 c	2.567 c	113.97 de	39.667 c	18.630 c	22.24 d	4.440 d	4.880 d	19.81 d	27.330 c
	T2	36.00 bc	5.667 c	20.667 c	3.400 bc	150.67 de	37.400 c	18.95 b	22.610 c	4.760c	5.250 c	20.88 c	28.89 bc
	T3	43.34 a	7.333 b	28.667 b	4.300 b	165.87 d	39.300 c	19.14 ab	22.79 b	5.010 b	5.540 b	21.74 b	29.84 bc
	T4	44.00 a	9.667 a	43.667 a	6.867 a	176.733 a	45.533 a	19.230 a	22.990 a	5.000 b	5.800 a	21.87 b	33.150 a
	Seasons	38.583 a	7.000	27.250	4.283	133.81 b	40.475	18.987	22.658	4.803	5.368	21.08 b	29.802
Combined	T1	29.667 c	5.333 c	15.667 c	2.583 c	111.20 d	38.667 b	18.620 c	29.667 c	4.435 c	4.870 d	19.81 d	27.320 c
	T2	35.375 b	5.458. c	19.333.c	3.375 bc	130.22 c	37.875 b	18.93 b	35.38 b	4.755 n	5.235 c	20.87 c	28.87 bc
	T3	41.50 a	7.500 b	28.500 b	4.183 b	142.70 b	38.883 b	19.125 a	41.50 a	5.015 a	5.530 b	21.72 b	29.828 b
	T4	44.00 a	10.000 a	43.333 a	6.767 a	170.533 a	44.250 a	19.095 a	44.0 a	5.125 a	5.795 a	22.23 a	32.015 a
	Seasons	37.635	7.073	26.708	4.227	138.664	36.919	18.942	37.635	4.833	5.358	21.157	29.507
LSD	Seasons	1.135	NS	NS	NS	9.432	NS	NS	NS	NS	NS	0.157	NS
	Treat.	3.270	1.244	5.048	0.867	11.220	1.809	0.152	0.066	0.155	0.110	0.202	1.696
	Treat. X Seasons	4.622	4.622	7.138	1.227	15.870	2.558	0.215	0.093	0.066	0.155	0.285	2.395

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الملخص العربي

أستجابة الفاصوليا الخضراء للري بالتنقيط التحت سطحي النبضي

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تهدف هذه الدراسة إلي تقدير مدى أستجابة نبات الفاصوليا إلي تطبيق نظام الري النبضي بإستخدام الري بالتنقيط التحت سطحي ومدى أنعكاس ذلك على الأنتاجية والأستفادة من العناصر السمادية بالإضافة إلى تقييم كفاءة أستخدام المياه لنبات الفاصوليا تحت الظروف المصرية. ولتطبيق ذلك تم أستخدام أربع معاملات للري والتي تعتمد أساساً على عدد النبضات أي عدد المرات التي يتم فيها إضافة المياه في الرية الواحدة والتي تتراوح من نبضة واحدة والتي تمثل المعاملة الأولى إلي أربع نبضات والتي تمثل المعاملة الرابعة، تمت الزراعة خلال موسمين ٢٠٠٨ و ٢٠٠٩. وجد من الدراسة أن زيادة عدد النبضات يؤثر تأثيراً معنوياً على زيادة النمو الخضري والأنتاجية لنبات الفاصوليا حيث تم الحصول على أقل وأقصى أنتاجية والتي تقدر ب ١٧٥١٦.٨٠ كجم\هكتار و ٢٤٣٠٧.٣٧ كجم\هكتار للمعاملة الأولى والرابعة على التوالي للموسم الأول ٢٠٠٨، بينما كانت أقل وأقصى انتاجية للموسم الثاني ٢٠٠٩ هي ١٧٣٢٦.٤ كجم\هكتار و ٢٤٠٨٥.٦٠ كجم\هكتار للمعاملة الأولى والرابعة على التوالي. كان الأستهلاك المائي للمحصول (ET) خلال موسمي الزراعة ٢٠٠٨ و ٢٠٠٩ هو ٣٨٢مم و ٣٩٠ مم على التوالي، وجد أن كفاءة أستخدام المياه (WUE) وهي ناتج قسمة المحصول الناتج على البخر-نتح الحادث خلال موسم النمو، وكفاءة أستخدام مياه الري (IWUE) وهي ناتج قسمة المحصول الناتج علي الكمية الكلية لمياه الري المضافة خلال موسم النمو، تزداد بزيادة عدد النبضات حيث تتراوح كفاءة أستخدام المياه بين ٤.٥٩ كجم\م٣ إلى ٦.٨٤ كجم\م٣ للمعاملة الأولى والرابعة على التوالي لموسم ٢٠٠٨ بينما لموسم ٢٠٠٩ فأن كفاءة أستخدام المياه كانت ٤.٤٤ كجم\م٣ و ٦.٦٤ كجم\م٣ للمعاملة الأولي والرابعة على التوالي. تم الحصول على أعلى تركيز للعناصر السمادية في نبات الفاصوليا من المعاملة الرابعة بينما كان أقل تركيز تم الحصول عليه من المعاملة الأولى.

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