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Performance of Some Bean (*Phaseolus Vulgaris* L.) Varieties under Different Irrigation Systems and Regimes

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Abstract: Two field experiments were carried out for the two successive growing seasons of 2004 and 2005 in a silt clay loam soil at the Experimental Farm of the Faculty of Agriculture, Ain Shams University, Qalubia Governorate, Egypt. The aim of this study was to investigate the effect of different irrigation systems (surface drip, subsurface drip, gated pipes and furrow irrigation) and water regimes (100%, 80% and 60% Eto) on vegetative growth, productivity and WUE of snap bean (Phaseolus vulgaris L.) varieties Paulista and Bronco. Results showed that surface drip (SD) and/ or subsurface drip (SSD) systems exhibited the highest values of vegetative growth (plant height, No. branches, No. leaves, No. pods, leaves area and dry weight of stem, leaves, pods and total plant); pods yield (kg/fed) and WUE followed by gated pipes (GP) meanwhile furrow irrigation (FI) recorded the lowest values in the same concern. Increasing irrigation treatment up to 100% ETo exhibited the highest values of vegetative growth. However, the highest values of pods yield/fed. and WUE were achieved by 80% Eto treatment. Paulista variety exhibited its superiority in growth parameters. However, Bronco variety surpassed Paulista one in pods yield /fed and WUE. It could be concluded that under the conditions of the experiment or any other similar conditions, Bronco bean variety is recommended in cultivation (for export or local marketing) with irrigation at 80% Eto, corresponding to1556 m3/ fed. / season, using surface or subsurface drip irrigation systems due to its superiority in green pods yield/ fed. with higher efficiency in using water (WUE) and finally higher net profits/ fed.

Key words: Phaseolus vulgaris, irrigation systems, irrigation regimes, yield, WUE.

INTRODUCTION

Snap bean *(Phaseolus vulgaris L.)* is widely used as protein source with highly nutritive value in human nutrition in Egypt. It is cultivated for its green pods as well as dry seeds. Green bean is considered one of the most important vegetable crops grown in Egypt, which occupies a great figure in local consumption and export. Therefore, expansion in cultivation of green beans is growing rapidly. Besides increasing the protein content of the meal, beans have contributed to improving the protein quality in diet because bean protein is rich in lysine. The cultivated area of green bean in Egypt is 2.4% of total world cultivated area, producing about 3.5% of total world production of bean (FAO Statistics, 2004). The first step in production of high quality exportable beans yield is cultivating the appropriate cultivars because some varieties are more suitable for the European consumers than others. Many investigators reported that bean growth, pods or seed yield and total exportable yield are greatly affected by genotype of variety (Barbieri and Pascale, 1992; El- Sayed, 1996; Mohamed, 1997; Singer *et al*., 2001, Amer *et al.*, 2002-a; and Abdel-Mawgoud *et al.,* 2005). Moreover, Amer *et al.*, (2002-a) concluded that the differences in pods yield of bean varieties might be attributed to the different genetic potentiality of every variety.

The performance of any crop depends not only on its genetic characteristics but also on the surrounding environmental conditions particularly methods of irrigation and water supply. Therefore, growers have to adopt modern techniques of cultivation, and improve water use efficiency (WUE). Irrigation systems such as surface drip irrigation (SDI), subsurface drip irrigation (SSDI), gated pipes compared with conventional surface furrow irrigation are practiced for increasing growth, and yield of most vegetable crops, saving irrigation water and improving water use efficiency. Using modern irrigation systems (surface and subsurface) and modified irrigation systems (gated pipes) in growing vegetable crops led to increased growth, yield and WUE and decreased water

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consumption (Al-Jammal *et al.*, 2001; Krnak *et al.*, 2002; Gengoglan *et al.*, 2005; Mehana, 2005; Barrios-Diaz *et al.,* 2006 and Erdem *et al*., 2006). Water is the key factor of the agricultural production and development of different crops under arid and semi-arid conditions. Crop growth and yield are affected by the method of water delivery and the available water in the soil layers at the effective root zones. It is highly desirable to obtain higher yield using the least possible quality of water. Increasing irrigation level increased growth, green pods yield and WUE of beans (Al – Kaisi *et al.*, 1999; Amer *et al*., 2002- b; Metin *et al.*, 2005, Abdel-Mawgoud, 2006). The same results were obtained by El-Noemani *et al*. (2009) on pea plants. This investigation aimed to study the effect of different irrigation methods and levels of irrigating water on growth, yield and water use efficiency of some new snap bean varieties.

MATERIALS AND METHODS

Land and Crop:

Two field experiments were conducted during the two successive growing seasons (2004 and 2005) at the Experimental Farm of Faculty of Agriculture, Ain Shams University, Qalubia Governorate, Egypt. In both seasons, beans (*Phaseolus vulgaris L.*) varieties Paulista and Bronco were used. The preceding crop was wheat. Sowing date was 25th September in the two experimental seasons, however, plants were sown in rows with 60 cm spacing and hills were spaced 10 - 15 cm apart. Thinning was done before first irrigation (Mohaya) to secure two plants/ hill. Green pods were picked four times; the last pick was done at 86 and 94 days from sowing in the first and second season, respectively. The aim of this study was to study the effect of irrigation treatments; (100%, 80% and 60% of ETo) under different irrigation systems (surface drip, subsurface drip, modified surface irrigation systems by using gated pipes technique and traditional furrow irrigation) on growth, yield and WUE of the aforementioned two beans varieties. Fertilizer requirements of beans crop were added according to recommendations of Vegetable Crop Research Institute, ARC, Ministry of Agriculture and Land Reclamation under the studied area. The recommendations are 200 kg/ fed. of calcium super phosphate (15.5 % P_2O_5), 50 kg/ fed. of ammonium sulphate (20.5 % N) and 25 kg/ fed. of potassium sulphate (48 % K_2O) during the seed bed preparation. While additional 50 kg/ fed. of ammonium sulphate and 25 kg/ fed. of potassium sulphate were added at the first irrigation (Mohaya), two weeks after sowing date.

Irrigation treatments were started two weeks after the first irrigation (Mohaya) and irrigation was withheld after the last pick. The other agricultural practices were done as usual in the district. Some physical and chemical analyses of the soil profile and water (as means over the two seasons) were conducted according to the method described by Klute and Dirksen (1986), as shown in Tables (1 and 2). Field capacity (F.C.) and permanent wilting point (P.W.P.) were determined according to Black, 1965.

Irrigation Methods:

Four irrigation methods were selected to irrigate beans plants. The first is surface drip system (SDI) including GR, 4L/h emitters at 30 cm spacing. Polyethylene lateral with diameter of 16 mm were used at 70 cm spacing. The second method is subsurface drip irrigation (SSDI), the same practices were used for laterals but they were fixed at 15 cm depth under soil surface. The third method is gated pipes (GP), polyethylene gates fixed on aluminum pipes of 160 mm in diameter (gated discharge is 4 m3/h and distance between gates was 70 cm, at 0.15 bar pressure). The fourth method was traditional furrow irrigation, 70 cm apart.

Irrigation Treatments:

Three water application rates were applied for irrigating beans crop; i.e. irrigation at 100%, 80%, and 60% of reference crop evapotranspiration (Eto) calculated from meteorological data. Water consumptive use was calculated according to the climate data recorded at the Experimental Farm of Faculty of Agriculture, Ain Shams University which is located at Shalakan, Qalubia Governorate. Quantity of crop water requirements (Eto) values were determined according to (FAO, 1991). Water consumptive use and water requirements are presented in Table (3).

Irrigation Water Requirements:

The amount of irrigation water for green beans was applied by flow meter after it was calculated according the following equation:

$$IW = \left[\frac{ETo * Kc * Kr * I}{Ea} + LR\right] * 4.2$$

Where:
IW = Irrigation water applied m^3 / fed / irrigation
ET_0 = Reference Evapotranspiration (mm/day)
Kc = Crop coefficient.
Kr = Reduction factor (Keller and Karmeli, 1975)
I = Irrigation interval, day
Ea = Irrigation efficiency, 90%.
LR = Leaching requirement = 10% of the total water amount delivered to the treatment.

Varieties:

Two beans varieties; i.e. Paulista and Bronco were investigated.

Experimental Design:

The experimental design used was split – split plot one with four replications. The studied irrigation systems, water treatments, and bean varieties were assigned in main plots, sub main plots and sub – sub main plots, respectively. Design of the experimental factors and treatments in the field is illustrated in Fig. (1).

Measurements and Calculations:

One vegetative sample of five plants was taken in the last pod picking which was at 86 and 94 days after sowing in the first and second season, respectively. The following characters were measured:

Growth Parameters:

i.e.; Plant height, (cm); Number of branches / plant; Number of leaves / plant; Number of pods / plant; Area of leaves / plant, (cm2); Dry weight of stem / plant, (g) ; Dry weight of leaves / plant, (g); Dry weight of roots / plant, (g); Dry weight of pods / plant, (g) and Total plant dry matter (g).

Productivity:

yields of the different collections per plot were summed together to calculate the total green pods yield/ plot, and then total green pods yield / fed. was calculated.

Water Use Efficiency:

Water use efficiency (WUE) is an indicator of the efficiency of irrigation in increasing crop yield. Water use efficiency of green pods yield was calculated from the following equation (Vites, 1965): WUE of green pods yield = Total green pods yield (kg/ fed.) / Total applied irrigation water (m^3/ fed.)

Statistical Analysis:

Data were subjected to the proper statistical analysis according to the method prescribed by Snedecor and Cochran (1982). Means were verified according to the Duncan's multiple range test (1955).

Table 1: Some physical and chemical properties of soil at Shalakan, Qalubia, average of 2004 and 2005 seasons.

A. Some physical properties

Depth (cm)	Coarse sand (%)	Fine sand (%)	Silt (%)	Clay (%)	Texture	F. C. %	P.W.P%	B.D (g / cm^3)
0-15	0.80	27.80	41.6	29.8	SCL	35.46	19.10	1.25
15-30	0.70	27.50	41.2	30.6	SCL	35.21	19.24	1.28

B.Some chemical properties

Depth (cm)	EC dS/ m	pH	Soluble cations (meq/l)				Soluble anions (meq/ l)			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO3^{--}$	$HCO3^{-}$	Cl^{-}	$SO4^{--}$
0-15	0.26	7.7	0.40	0.48	0.41	0.19	---	0.63	0.49	0.36
15-30	0.23	7.6	0.46	0.35	0.51	0.18	---	0.76	0.51	0.23

F.C.: Field capacity, P.W.P: Permanent wilting point, B.D.: Bulk density and SCL: Silty- clay loam.

Table 2: Some chemical analysis of irrigation water at Shalakan, Qalubia during 2004 and 2005 seasons.

Season	EC dS/m	pH	Soluble cations (meq/l)				Soluble anions (meq/l)			
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO3^{--}$	$HCO3^{-}$	Cl^{-}	$SO4^{--}$
2004	0.37	7.3	2.73	1.40	2.19	0.21	---	2.40	2.50	1.6
2005	0.35	7.4	2.81	1.30	2.46	0.23	---	2.30	2.70	1.8

Table 3: Seasonal, daily water consumptive use (W.C.U.) and water requirements as affected by irrigation systems and treatments during 2004 and 2005 seasons.

Variable Treatments		Growth period		No. of irrigations /season		Water Consumption m^3/fed. /day		Water m Consumption m^3/fed. /season		*WaterRequirements m^3/fed. /season	
Irrig.Systems	ETo	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2
SD	100%	86	94	9	13	12.85	14.58	1105	1370	1505	1770
	80%	86	94	9	13	10.98	12.30	944	1156	1344	1556
	60%	86	94	9	13	9.11	10.02	783	942	1183	1342
SSD	100%	86	94	9	13	12.85	14.58	105	1370	1505	1770
	80%	86	94	9	13	10.98	12.30	944	1156	1344	1556
	60%	86	94	9	13	9.11	10.02	783	942	1183	1342
GP	100%	86	94	4	5	18.56	19.01	1597	1787	1997	2187
	80%	86	94	4	5	15.56	15.85	1338	1490	1738	1890
	60%	86	94	4	5	12.53	12.68	1078	1192	1478	1592
FI	100%	86	94	4	5	24.60	25.34	2116	2382	2516	2782
	80%	86	94	4	5	20.38	20.90	1753	1965	2153	2365
	60%	86	94	4	5	16.16	16.48	1390	1549	1790	1949

S 1 = 1st Season S 2 = 2nd Season * = including sowing irrigation

RESULTS AND DISCUSSION

Effect of Irrigation Systems:

1. Vegetative Growth Characteristics:

Data in Tables (4 & 5) showed the effect of irrigation systems; i.e. surface, sub-surface drip irrigation, modified surface irrigation using gated pipes and traditional furrow irrigation system on vegetative growth of bean plants. In the first season, data showed that the higher values for plant height, pods number, stem and pods dry weight were found in either surface or sub-surface drip irrigation followed by gated pipes. The lowest values were obtained at furrow irrigation. In addition data showed that the highest values of branches no., leaves no., leaves area, dry weight of leaves as well as the total plant were recorded at surface followed by sub-surface drip irrigation. Whereas, the lowest values were recorded at furrow irrigation. Furthermore, the differences between the four systems of irrigation were not significant for roots dry weight. In the second season, data showed in most cases that, either surface or sub-surface drip irrigation system surpassed the other two systems for plant height, branches No., leaves No., pods No., leaves area, dry weight of stem leaves, roots as well as total plant. On the other hand, data at furrow irrigation system recorded the lowest values in all studied parameters. In addition, the effect of irrigation systems was not significant on the dry weight of pods. Data showed that the effect of irrigation systems on bean growth parameters varied from one growth characters to another. For example, both surface and sub-surface drip irrigation systems had higher significant effect on most growth parameters in the first season compared to the other two systems. On the other hand, surface drip irrigation system was generally, more suitable. for obtaining higher growth parameters in the second one comparing with the other three systems of irrigation. The obtained results are in agreement with these of Kassem (2000), Haikel and Farid (2001), Kassab *et al.* (2005) and Mehana (2005).

2. Productivity and WUE Criteria:

Data in Figs. (2 & 3) showed the effect of irrigation systems; i.e. surface, sub-surface drip irrigation, gated pipes and furrow irrigation on productivity and WUE criteria of bean plants. In the first season, data showed that surface drip system exhibited the highest values of pods yield (kg/ fed) as well as WUE. Moreover, in the second season both surface and sub-surface drip irrigation systems were significantly equal in the same concern. However, the lowest significant values for the aforementioned characters were shown by furrow irrigation system. Whereas, gated pipes system ranked in between. The present results are in accordance with the findings of Al-Jammal *et al.*, 2001; Krnak *et al.*, 2002; Gengoglan *et al.*, 2005; Mehana, 2005; Barrios-Diaz *et al.*, 2006 and Erdem *et al.,* 2006). According to Phene (1991), improved yields under drip irrigation system could be resulted from maintaining the soil moisture at an optimum level through more frequent water applications.

Effect of Irrigation Regimes:

1. Vegetative Growth Characteristics:

Data found in Tables (4& 5) contain the effect of irrigation regimes, i.e. 100%, 80% and 60% of reference crop evapotraspiration (Eto) on vegetative growth of Phaseolus valgaris in 2004 and 2005 respectively. It is clear from Tables (4& 5) that a quite similar trend was obtained in both experimental seasons regarding the effect of irrigation on the studied growth parameters. In both seasons, plant height, branches No., leaves No., pods No., leaves area, dry weight of stem as well as total plant were increased significantly by increasing irrigation level to 100% Eto. With regard to dry weight of either roots or pods the differences were not significant between irrigation levels in both seasons. On the other hand, data indicated that, the medium level of water supply 80%

Eto ranked second whereas the low level of irrigation ranked third concerning their effect on the studied growth criteria; plant height, branches No., leaves No., pods No., leaves area dry weight of stem as well as total plant dry weight. Moreover, in the second season there were no significant differences among irrigation regimes in dry weight of leaves. These results coincided with those reported by Sing (1989), Ismail (2000) and Amer et al. (2002, a& b). who found that increasing irrigation levels significantly increased vegetative growth parameters of snap bean.

Moreover, El-Noemani, *et al.* (2009) on pea exhibited that increasing irrigation level up to 100% Eto increased vegetative growth (plant height, branches no., leaves area, as well as dry matter of stem and total plant). The strong influence of increasing irrigation up to the maximum level on plant height could be explained as a result of enhancing cell division and enlargement which need more water supplies (Hammad, 1991). (Fatthallah and Gawish, 1997) exhibited that the reduction in number of branches owing to the low soil moisture level may be due to the reduction in the uptake of nutritional elements that caused deterrence in the physiological processes needed for plant growth. Moreover, the increment in leaf area with increasing irrigation level could be attributed to the increased cell division and enlargement due to high soil moisture. The increase in dry matter of plants grown in high levels of soil moisture could be attributed mainly to the effect of water on some quantitative and qualitative changes in certain metabolic processes in the plant cell (Mahmoud,2000). Generally, it could be suggested that increasing applied irrigation water to plants led to keeping higher moisture content in the soil and this in turn favored the production of dry matter content of different plant parts. This indicated the importance of water supply for increasing plant growth. On the contrary, shortening plant height and reduction in leaves area and lower dry matter under soil moisture stress may be explained that water stress caused stomatal closure and reduced minerals uptake by plants and hence affected plant growth.

2. Productivity and WUE Criteria:

Data shown in Figs.(2 & 3) contain the effect of irrigation regimes; i.e. 100%, 80% and 60% of evapotranspiration (Eto) on productivity WUE criteria of bean plants (Phaseolus vulgaris L.) in 2004 and 2005 experimental seasons. It is clear from Figs.(2 & 3) that there are significant differences due to variation of irrigation rates in the two studied parameters in both growth seasons. In the first season, it is obvious from data that the highest values of pods yield/ fed. and WUE was achieved by 80% Eto treatment, whereas irrigation at either 100% or 60% showed significant decreases comparable to 80% Eto treatment. It could be concluded that water stress treatment (60% Eto) led to decrease in pods yield/fed. compared with higher levels of irrigation, i.e. 80% and 100% Eto. The results reported here in this investigation coincided with those previously obtained by Boutraa and Sanders (2001); Singer *et al*. (2001); Amer *et al.* (2002-b); Isik *et al*. (2005); Metin *et al*. (2005); Onder *et al*. (2005); Barrios-Diaz *et al*. (2006) and Erdem *et al*. (2006). Similarly, El-Noemani, *et al.* (2009) on pea found that WUE for green pods and dry seeds yields showed the highest values when pea plants were irrigated at 80% Eto, while 60% Eto exhibited the lowest values. On the contrary, they showed that increasing irrigation level up to 100% Eto increased green pods and dry seeds yields / fed.

In the same connection Abdel-Mawgoud *et al*. (2005) also reported that increasing irrigation rate may increase water availability in the root zone resulting in improving plant water status and better stomatal conductance which eventually reflects on photo assimilates production. These effects are translated in terms of total fresh and dry weights of the plant which showed a positive response to increasing irrigation level. Moreover, Abdel-Mawgoud (2006) stated that increasing irrigation level increased green pods yield. The increase in pods yield by increasing irrigation level may be due to that increasing applied water increased moisture content in the soil that reflects on plant metabolism and production of higher yield. (Hsiao and Acevedo, 1974) revealed that the detrimental effect of water stress on total yield of dry seeds and its components of pea plants may be attributed to the reduction in vegetative growth. Besides, low soil moisture adversely affected the hormonal balance, plant development, translocation and partition of assimilates among different plant organs which in turn may negatively affect dry seeds yield.

Effect of Varieties:

1. Vegetative Growth Characteristics:

Growth parameters of bean varieties in the two experimental seasons of 2004 and 2005 are exhibited in Tables (4& 5). Data showed that growth parameters; i.e. plant height, branches No., leaves No., pods No., leaves area, stem dry weight and total plant dry weight in two seasons, as well as leaves and roots dry matter in the second season were significantly affected by bean varieties. With regard to the dry weight of pods, there were no significant differences between the two varieties in the two growing seasons. Moreover, differences between varieties in dry weight of leaves and roots did not reach the level of significance in the

first season. It is worthy to mention that Paulista variety exhibited its superiority in all aforementioned growth characters. Contrarily, in both growing seasons Bronco variety showed its inferiority against Paulista variety in the same regard. The different behavior of varieties observed in the studied characters might reflect the differential expressivity of certain genes during autogenetic processes. These results agree with those of Nassar (1986) on snap bean, Sohair *et al.* (1998) on soybean, Abou El-Hassan *et al.* (1993) on bean and Amer et al. (2002a) on bean.

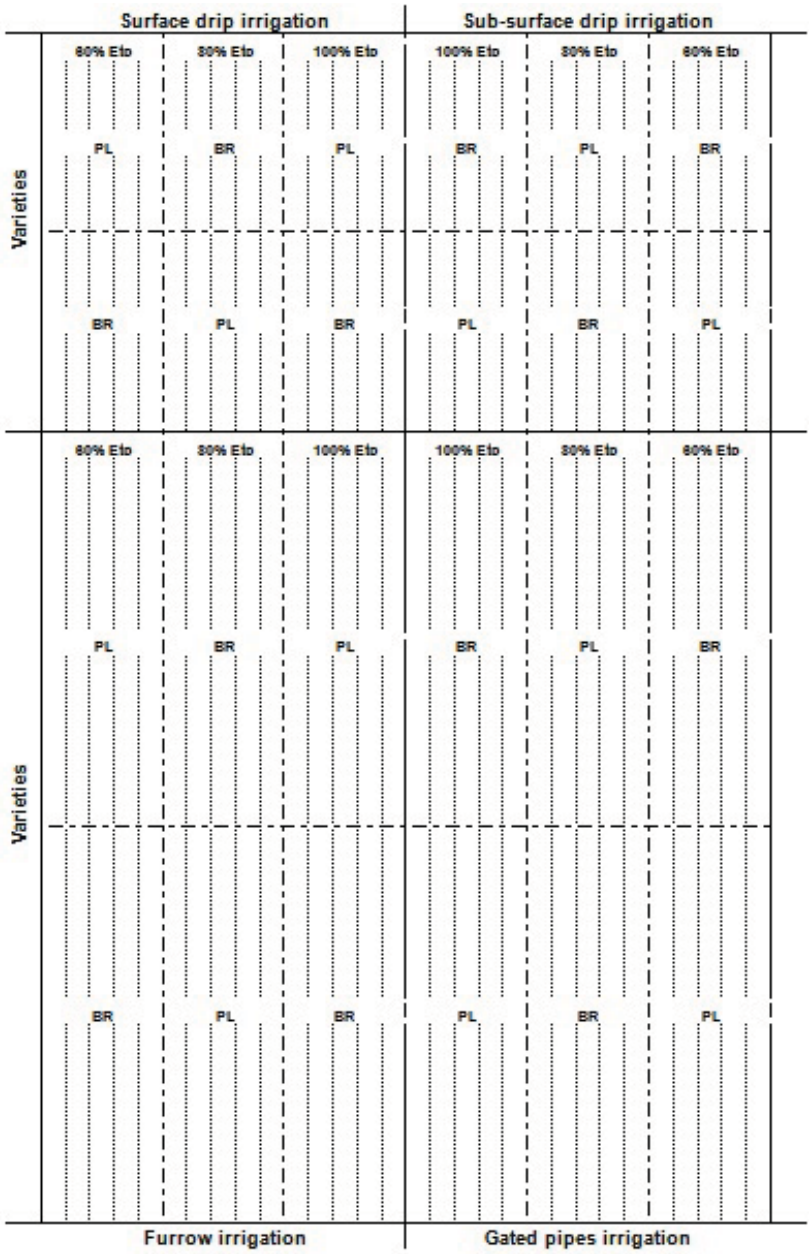

Fig. 1: Design of the experimental factors and treatments in the field.

2. Productivity and WUE Criteria:

Pods yield and WUE of bean varieties in the two experimental seasons of 2004 and 2005 are exhibited in Figs.(2 & 3) Data showed that the two studied parameters were generally significantly influenced by varieties. In this regard, Bronco variety surpassed Paulista one in the aforementioned characters in the two seasons. The present results are in agreement with those obtained by Abdel-Maugoud (2005) who found that pods yield differed among beans cultivars. Moreover, Amer *et al.* (2002-a) concluded that the differences in pods yield of bean varieties might be attributed to the different genetic potentiality of every variety.

Effect of Interaction:

1. Vegetative Growth Characteristics :

Effect of interaction among irrigation systems, irrigation regimes and varieties on vegetative growth characters is exhibited in Tables (6 & 7). Significant differences due to interaction were attained in all growth parameters in both experimental seasons except for roots dry weight in the two seasons as well as leaves, pods and total plant dry weight in the second season. Data demonstrated that no obvious trend could be detected in the two seasons regarding the highest and lowest values of the studied criteria. It is worthy to mention that in most cases the highest values of the significantly affected characters in the two seasons were exhibited by Paulista variety when its plants were irrigated at either 100 or 80% Eto under both surface and sub-surface drip irrigation systems.

2. Productivity and WUE Criteria:

Effect of interaction among irrigation systems, irrigation regimes and varieties on productivity and WUE criteria is exhibited in Table (8). Significant differences due to interaction were attained in the two studied parameters in both experimental seasons. The highest significant interaction values of pods yield / fed. were 3748 and 4720 kg/ fed. in the first and second season, respectively for Bronco variety irrigated at 80% of Eto under surface drip irrigation system. Meanwhile, the lowest significant interactions values of pods yield/fed were 1492 and 2091 kg/fed. in the first and second season, respectively for Bronco variety irrigated at 60% Eto under furrow irrigation system. With regard to the highest interaction value of WUE, it was also recorded by Bronco variety irrigated at 60% of Eto under surface drip irrigation system.

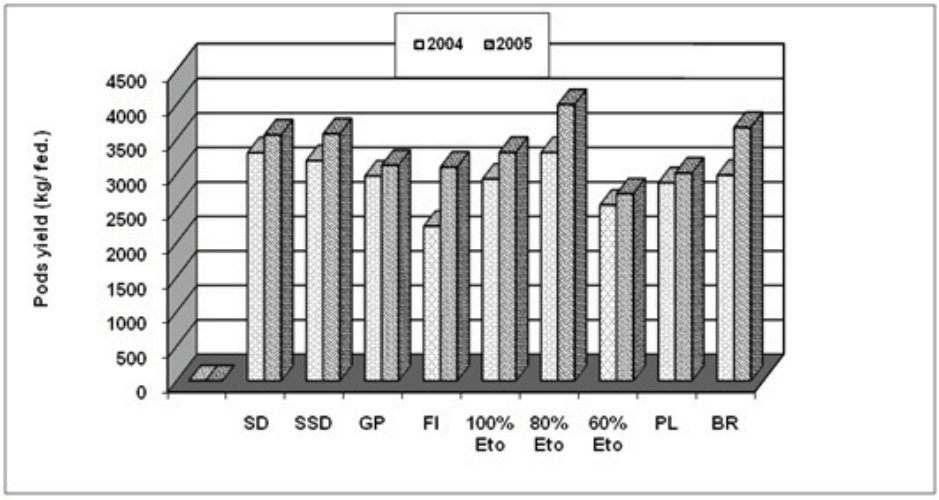

Fig. 2: Effect of irrigation systems, irrigation regimes and varieties on green pods yield/ fed. of beans in Shalakan - Qalubia during 2004 and 2005 seasons.

Water Relations:

Data in Table (3) indicated that the length of irrigation period differed from one season to another, where it was 86 days and 94 days for the first and second growth season, respectively. Moreover, number of irrigation was; 9 and 13 for SD and SSD; 4 and 5 for GP and FI, in the first and second season of

investigation, respectively. Regarding total water consumption (m3/ fed./ season), data in Table (3) exhibited that it varied from one season to another according to meteorological components. In addition, total water consumption also varied among irrigation systems and application rates, where in both SD and SSD it was 1105 and 1370; 944 and 1156; 783 and 942 for 100% , 80% and 60% Eto in the first and second season of growth, respectively. Whereas, in GP it was 1597 and 1787; 1338 and 1490; 1078 and 1192 for 100%, 80% and 60% Eto in the first and second season of growth, respectively. Moreover, in FI it was 2116 and 2382; 1753 and 1965; 1390 and 1549 for 100%, 80% and 60% Eto in the first and second season of study, respectively. Water consumption (m3/ fed./ day) was calculated by dividing total water consumption by days of application period, so it varied among application rates and from one season to another. Since water requirements was calculated on the basis of total water consumption, so the two parameters showed the same trend.

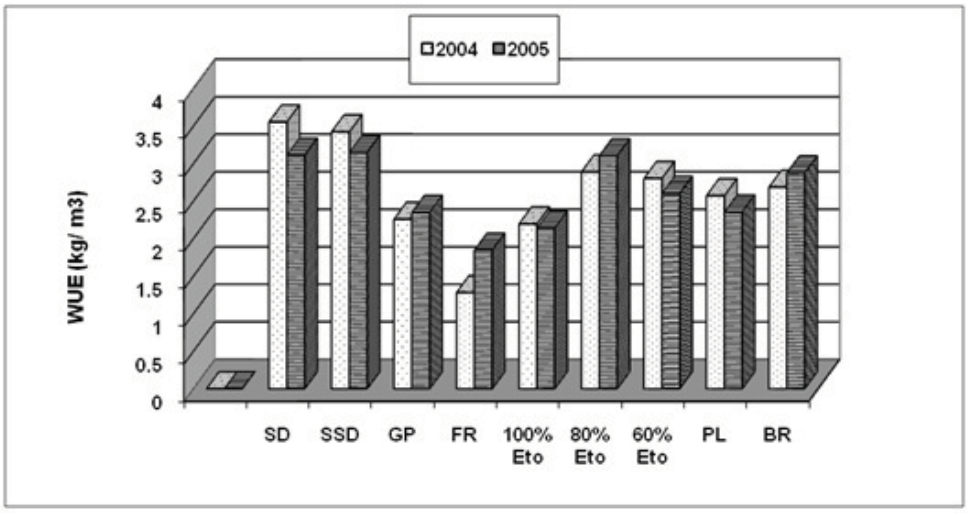

Fig. 3: Effect of irrigation systems, irrigation regimes and varieties on WUE of beans in Shalakan - Qalubia during 2004 and 2005 seasons.

Table 4: Effect of irrigation systems, irrigation regimes and varieties on vegetative growth characters of beans in Shalakan - Qalubia during 2004 season.

Variables Treatments	Growth characters					Dry weight (g)				
	Plant heigt (cm)	Branches No./plant	Leaves No./plant	Pods No./plant	Leaves area (cm)	Stems	Leaves	Roots	Pods	Total plant
SD	50.4 a	5.08 a	39.90 a	2.24 b	2548 a	6.24 a	4.76 a	1.10 N.S.	0.42 a	12.52 a
SSD	52.9 a	4.71 b	37.99 b	2.29 a	2457 b	6.23 a	4.13 ab	1.10 N.S.	0.55 a	12.01a
GP	43.4 b	3.87 c	34.61 c	0.90 c	1905 c	4.53 b	3.63 bc	1.07 N.S.	0.19 b	9.42 b
FI	40.6 c	3.66 d	31.79 d	0.78 d	1290 d	3.83 c	2.73 c	1.03 N.S.	0.16 b	7.75 c
100% Eto	48.4 a	4.58 a	39.83 a	1.68 a	2347 a	5.81 a	4.44 a	1.16 N.S.	0.34 N.S.	11.76 a
80% Eto	46.7 b	4.24 b	34.90 b	1.52 b	1904 b	5.01 b	3.48 b	1.07 N.S.	0.32 N.S.	9.87 b
60% Eto	45.5 b	4.16 c	33.48 c	1.46 c	1900 b	4.80 c	3.52 b	0.99 N.S.	0.33 N.S.	9.65 b
PL	48.8 a	4.38 a	39.27 a	1.66 a	2141 a	5.32 a	3.96 N.S.	1.10 N.S.	0.35 N.S.	10.73 a
BR	44.9 b	4.28 b	32.88 b	1.45 b	1959 b	5.10 b	3.66 N.S.	1.05 N.S.	0.31 N.S.	10.12 b

Table 5: Effect of irrigation systems, irrigation regimes and varieties on vegetative growth characters of beans in Shalakan-Qalubia during 2005 season.

Variables Treatments	Growth characters					Dry weight (g)				
	Plant heigt (cm)	Branches No./plant	Leaves No./plant	Pods No./plant	Leaves area (cm)	Stems	Leaves	Roots	Pods	Total plant
SD	46.89 a	8.811 a	25.03 a	3.389 b	2592 b	4.736 a	6.101 a	1.727 a	0.515	13.080a
SSD	47.99 a	8.384 b	23.42 b	3.623 a	2629 a	4.998 a	5.885 a	1.714 a	0.561	13.160a
GP	46.33 a	8.127 c	21.33 c	3.266 b	2007 c	3.584 b	3.946 b	1.309 b	0.346	9.186 b
FI	42.72 b	8.096 c	18.67 d	2.318 c	1754 d	2.807 c	3.928 b	1.094 c	0.436	8.266 c
100% Eto	47.49 a	8.438 a	22.75 a	3.417 a	2649 a	4.296 a	5.653 N.S.	1.512 N.S.	0.533	11.990 a
80% Eto	46.08 b	8.325 ab	21.98 b	3.313 a	2107 b	4.000 b	4.654 N.S.	1.450 N.S.	0.452	10.560 b
60% Eto	44.38 c	8.301 b	21.61 c	2.717 b	1980 c	3.799 c	4.588 N.S.	1.421 N.S.	0.408	10.220b
PL	48.16 a	8.595 a	23.74 a	3.619 a	2592 a	4.467 a	5.741 a	1.598 a	0.412	12.220 a
BR	43.80 b	8.114 b	20.49 b	2.678 b	1899 b	3.596 b	4.189 b	1.324 b	0.517	9.626 b

Table 6: Effect of interaction among irrigation systems, irrigation regimes and varieties on vegetative growth characters of beans in Shalakan - Qalubia during 2004 season.

Variables Treatments			Growth characters					Dry weight (g)				
			Plant heigt (cm)	Branches No./plant	Leaves No./plant	Pods No./plant	Leaves area (cm)	Stems	Leaves	Roots	Pods	Total plant
SD	100% Eto	PL	53. 6 e	5.4 0 b	42.6 7 bc	3.0 7 a	2941 e	8.1 8 b	5.8 1 abc	1.3 4 N.S.	0.5 2abcd	15.8 4 a
		BR	53. 9 d	7.0 0 a	56.53 a	1.9 3 e	4085 a	8.4 8 a	7.0 2 a	1.0 7 N.S.	0.3 3 bcdef	16.9 1 a
	80% Eto	PL	44. 5 p	4.4 d 0 e	30.60 ij	3.0 7 a	1145 m	3.8 9 mno	2.3 4 ghi	1.1 5 N.S.	0.5 6 abc	7.94 ij
		BR	49. 9 h	4.8 7 c	42.80 bc	1.4 7 f	3039 d	6.3 3 e	6.2 3 ab	1.3 6 N.S.	0.2 4 cdef	14.16 b
	60% Eto	PL	48. 5 i	4.3 3 e	37.33 defgh	1.4 0 f	2080 h	5.7 3 f	3.9 0 efg	0.8 3 N.S.	0.24 cdef	10.7 0 def
		BR	52. 1 f	4.4 7 de	29.47 ij	2.5 3 c	1995 h	4.8 3 jk	3.2 5 fghi	0.8 5 N.S.	0.6 4 ab	9.57 efghi
SSD	100% Eto	PL	60. 9 a	4.3 3 e	40.67 bcdef	2.00 de	3457 b	6.61 d	5.14 bcde	1.27 N.S.	0.46 abcde	13.48 bc
		BR	45.9 m	4.73 cd	36.33 fgh	3.00 a	1736 j	4.76 k	2.94 fghi	1.02 N.S.	0.66 ab	9.38 fghi
	80% Eto	PL	56.3 c	5.27 b	44.20 b	2.73 b	2231 g	6.54 de	3.78 efgh	1.16 N.S.	0.70 a	12.18cd
		BR	50. 8 g	4.4 7 de	36.73 efgh	1.27 g	1984 h	6.92 c	3.59 efghi	1.04 N.S.	0.28 cdef	11.83d
	60% Eto	PL	56. 5 b	5.4 7 b	42.4 0 bcd	2.13 d	3325 c	6.91 c	5.64 abcd	0.97 N.S.	0.57 abc	14.08 b
		BR	47. 3 k	4.0 0 fg	27.6 0 jk	2.6 0 c	2012 h	5.63 fg	3.71 efghi	1.11 N.S.	0.65 ab	11.11 de
GP	100% Eto	PL	41.2 r	3.67 hi	41.67 bcde	1.13 gh	1766 j	3.80 no	4.47 cdef	1.2 6 N.S.	0.39 abcdef	9.92 efgh
		BR	46. 3 l	3.4 7 hij	32.60 hij	0.5 3 k	1769 j	5.4 2 gh	3.4 6 efghi	1.0 7 N.S.	0.1 0 f	10.0 4efg
	80% Eto	PL	48. 1 j	4.2 0 ef	36.73 efgh	0.8 7 i	2707 f	5.07 ij	4.27 cdef	1.02 N.S.	0.23 cdef	10.5 8 def
		BR	41. 5 q	3.8 0 gh	24.12 kl	0.8 7 i	1889 i	4.73 k	3.44 efghi	0.98 N.S.	0.23 cdef	9.38 fghi
	60% Eto	PL	45. 7 n	4.4 0 de	43.60 bc	0.80 ij	1833 ij	3.9 7 lmno	2.8 8 fghi	1.39 N.S.	0.08 f	8.32hi
		BR	37. 6 t	3.67 hi	28.93 ijk	1.20 gh	1468 k	4.2 0 l	3.29 fghi	0.72 N.S.	0.08 f	8.29 hi
FI	100% Eto	PL	45. 7 n	4.4 0 de	38.73 cdefg	1.13 gh	1511 k	5.2 5 hi	4.00 defg	1.11 N.S.	0.20 def	10.56 def
		BR	39. 7 s	3.6 7 hi	29.47 ij	0.67 j	1507 k	4.0 1 lmn	2.70 fghi	1.14 N.S.	0.08 f	7.94 ij
	80% Eto	PL	44. 9 o	3.4 0 ij	33.80 ghi	1.07 h	1242 l	3.7 0 o	1.91 i	0.88 N.S.	0.13 ef	6.62 jk
		BR	37. 2 u	3.53 hij	30.20 ij	0.80 ij	998 n	2.9 0 p	2.26 ghi	0.98 N.S.	0.17 def	6.30 k
	60% Eto	PL	39. 8 s	3.27 j	38.80 cdefg	0.53 k	1454 k	4.16 lm	3.44 efghi	0.86 N.S.	0.13 ef	8.58 ghi
		BR	36. 5 v	3.67 hi	19.73 l	0.4 7 k	1030 n	2.9 8 p	2.0 8 hi	1.2 3 N.S.	0.2 2 cdef	6.51 jk

Table 7: Effect of interaction among irrigation systems, irrigation regimes and varieties on vegetative growth characters of beans in Shalakan - Qalubia during 2005 season..

Variables Treatments			Growth characters					Dry weight (g)				
			Plant heigt (cm)	Branches	Leaves No./plant	Pods No./plant	Leaves No./plant	Stems area (cm)	Leaves	Roots	Pods	Total plant
SD	100% Eto	P	48.1 abcdef	8.733 bcde	33.1	4.73	346	4.72 bcd	7.33	1.73	0.26	14.05
		L	3 g		3 a	0 ab	8 c	0 ef	3 N.S.	3 N.S.	7 N.S.	0 N.S.
		B	47.4 abcdef	9.667 ab	22.9	3.80 bcdef	252	5.74	7.50	1.46	0.57	15.27
		R	7 gh		3 de	0 ef	2 g	3 ab	0 N.S.	3 N.S.	2 N.S.	9 N.S.
	80% Eto	P	48.2 abcdef	10.07	29.4	4.47	334 8 d					
		L	0 g	0 a	0 b	0 abc						
		B	45.0	8.467 abcde	18.4	1.80	226	3.99	5.86 N.S	1.74 N.S	0.72 N.S	12.32
		R	7	f	0 ghij	0 gh	4 i	0 efgh	3	7	7	3
	60% Eto	P	51.7	9.467 abc	24.7	2.46	186	3.32	7.55	1.84	0.48	13.19
		L	3 abc		3 cd	7 fgh	1 l	0 ghij	0 N.S.	3 N.S.	3 N.S.	3 N.S.
		B	40.7	6.467 h	21.6 defg	3.06cdef	209	3.97 efgh	4.09 N.S.	1.60 N.S.	0.43 N.S.	10.10 N.S
		R	3 I		0 h	7 g	0 j	0 i	3	7	7	7
SSD	100% Eto	P	49.0 abcdef	8.200 cdef	22.5 3	4.10 abc	385	5.98	8.83 N.S.	2.19 N.S.	0.60 N.S.	17.62 N.S.
		L	7		def	0 d	6 a	7 ab	3	7	3	0
		B	45.8 bcdefg	8.133 defg	22.4	4.50	282	3.33	2.87	1.78	0.73	8.713 N.S.
		R	7 hi		7 def	0 abc	4 e	0 ghij	7 N.S.	0 N.S.	0 N.S.	
	80% Eto	P	53.4	8.867 abcd	29.2	5.46	239	5.44 abc	8.57 N.S.	1.51 N.S.	0.59 N.S.	16.12 N.S.
		L	0 a	e	7 b	7 a	1 h	0 d	7	7	3	7
		B	42.9 fghi	8.870 abcd	21.8	3.93 bcd	149 n	5.14 bcd	3.85 N.S.	1.92 N.S.	0.38 N.S.	11.31 N.S.
		R	3	e	7 defg	3 e	5 o	7 e	3	3	7	0
	60% Eto	P	50.0 abcde	9.000 abcd	23.6	1.46	359	5.70	5.67 N.S.	1.88 N.S.	0.23 N.S.	13.50 N.S.
		L	0		0 cde	7 h	6 b	7 abc	7	3	3	0
		B	46.6 bcdefg	7.233 fgh	20.8 defg	2.27 gh	161 m	4.38 cdef	5.49 N.S.	0.98 N.S.	0.81 N.S.	11.67 N.S.
		R	7 hi		0 hi	0	1	0 g	3	3	7	3
GP	100% Eto	P	52.0 ab	8.300 cdef	27.2	2.40	266	5.04 bcd	5.78 N.S.	1.26 N.S.	0.18 N.S.	12.27 N.S.
		L	7		0 bc	0 fgh	8 f	3 e	0	7	7	7
		B	43.4 fghi	7.600 efgh	19.6 efghi	3.26 cdef	182	3.17 ghij	3.55 N.S.	1.42 N.S.	0.41 N.S.	8.550 N.S.
		R	0		0 j	7 g	3 l	0	3	0	0	
	80% Eto	P	45.8 bcdefg	7.933 defg	22.0 defg	4.80	243	4.13 defg	3.05 N.S.	1.49 N.S.	0.39 N.S.	9.068 N.S.
		L	0 hi		0	0 ab	8 h	0 h	0	3	5	
		B	43.6 efghi	7.730 defg	14.6 k	2.60 efgh	155 n	2.60 ij	3.24 N.S.	1.03 N.S.	0.26 N.S.	7.143 N.S.
		R	7		0	0	2	0	0	7	7	
	60% Eto	P	51.0 abcd	9.000 abcd	19.8 efghi	4.73	193 k	3.63 fghi	4.36 N.S.	1.56 N.S.	0.28 N.S.	9.840 N.S.
		L	0		0 j	0 ab	9	3	7	0	0	
		B	42.0 ghi	8.200 cdef	24.8 cd	1.80 gh	162 m	2.93 hij	3.68 N.S.	1.08 N.S.	0.53 N.S.	8.237 N.S.
		R	7		0	0	3	0	7	0	7	
FI	100% Eto	P	48.6 abcdef	8.333 cdef	16.8 jk	2.67 defg	222 I	3.60 fghi	5.53 N.S.	1.19 N.S.	0.76 N.S.	11.09 N.S.
		L	0		0	0 h	0	3	0	3	3	0
		B	45.3 cdefghi	8.533 bcde	17.3 ijk	1.87 gh	181	2.77 hij	3.81 N.S.	1.04 N.S.	0.73 N.S.	8.357 N.S.
		R	3	f	3	0	2 l	0	3	3	0	
	80% Eto	P	48.0 abcdef	6.867 gh	18.6 fghij	2.13 gh	183	2.03 j	5.16 N.S.	1.03 N.S.	0.27 N.S.	8.507 N.S.
		L	0 g		7	3	6 l	3	3	7	3	
		B	41.5 hi	7.800 defg	21.6 defg	1.30 h	153 n	1.98 j	3.22 N.S.	0.88 N.S.	0.37 N.S.	6.460 N.S.
		R	3		7 h	0	5 o	7	3	0	0	
	60% Eto	P	31.9 j	8.370 bcde	17.7 hijk	4.00 bcd	148	3.32 ghij	2.76 N.S.	1.48 N.S.	0.25 N.S.	7.830 N.S.
		L	3	f	3	0 e	8 o	0	3	7	7	
		B	40.9 i	8.670 bcde	19.8 efghij	1.93 gh	163 m	3.13 ghij	3.07 N.S.	0.92 N.S.	0.22 N.S.	7.355 N.S.
		R	0		0	3	5	0	5	3	3	

Table 8: Effect of the interaction among irrigation systems, irrigation regimes and varieties on green pods yield/ fed. of beans in Shalakan - Qalubia during 2004 and 2005 seasons.

			Pods yield (kg/fed.)		WUE/kgm^3	
	Variable Treatments		S1	S2	S1	S2
SD	100% Eto	PL	2890 i	3628 e	2.61 i	2.65 e
		BR	3716 ab	3111 f	3.36 f	2.27 gh
	80% Eto	PL	3270 e	4344 b	3.46 e	3.76 b
		BR	3748 a	4720 a	3.97 b	4.08 a
	60% Eto	PL	2721 k	2504 h	3.47 e	2.66 e
		BR	3489 c	3083 f	4.46 a	3.27 d
SSD	100% Eto	PL	3402 d	2491 h	3.08 h	1.82 l
		BR	2919 i	4309 b	2.64 i	3.15 d
	80% Eto	PL	3467 cd	3962 c	3.67 d	3.43 c
		BR	3659 b	4344 b	3.87 c	3.76 b
	60% Eto	PL	3145 g	2484 h	4.02 b	2.64 e
		BR	2555 l	3890 c	3.26 g	4.13 a
GP	100% Eto	PL	3014 h	2485 h	1.89 k	1.55 m
		BR	3041 h	3939 c	1.90 k	2.46 f
	80% Eto	PL	3150 g	3069 f	2.35 j	2.29 g
		BR	3166 fg	4277 b	2.37 j	3.19 d
	60% Eto	PL	2590 l	2184 i	2.40 j	2.02 ij
		BR	2853 ij	2790 g	2.65 i	2.58 ef
FI	100% Eto	PL	2069 n	2709 g	0.98 n	1.33 n
		BR	2341 m	3810 cd	1.11 m	1.87 kl
	80% Eto	PL	3227 ef	3613 e	1.84 k	2.14 hi
		BR	2788 jk	3700 de	1.59 l	2.19 gh
	60% Eto	PL	1524 o	2665 g	1.10 m	1.99 jk
		BR	1492 o	2091 i	1.07 m	1.56 m

Conclusions:

Form the results obtained in this investigation the following conclusions could be figured out:

1. Surface and sub-surface drip systems are recommended for growing bean varieties due to their superiority in pods yield (kg/ fed) and WUE.
2. Irrigation at 80% of Eto; i.e. 1556 m^3/ fed / season under both surface and subsurface drip systems, 1890 m^3 under gated pipes and 2365 m^3 under furrow irrigation, is recommended for irrigating snap bean varieties due to increases in pods yield/ fed. and WUE.
3. Finally, it could be concluded that under the conditions of the experiment or any other similar conditions, Bronco bean variety is recommended in cultivation (for export or local marketing) with irrigation at 80% Eto, corresponding to1450 m3/ fed./ season using SD or SSD irrigation systems due to its superiority in green pod yield with higher water use efficiency and so higher net profits/ fed..

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