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Response of Snap Bean Plants to Irrigation Regimes

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TWO EXPERIMENTS were performed in summer and autumn seasons of 1999 and 2000 at EL-Bosaily Protected Cultivation Site, west of Rosetta. Two green snap bean cultivars were uesd, *i.e.,* Emy (extra fine) and Paulista (fine type), to investigate the water requirements of green beans under EL-Bosaily conditions. Three treatments of irrigation regimes, according to Class A Pan, were used, *i.e.,* 100, 80, 60% Class A Pan. Results indicated the application of 100% Class A Pan treatment produced the tallest plants and the highest number of leaves per plant in summer and autumn seasons while leaf area, fresh and dry weight of leaves were not statistically affected by irrigation treatments, except fresh weight of leaves in summer season which was increased by 100% Class A Pan treatment. In summer season, Paulista plants were taller than Emy plants, regardless irrigation treatments. Irrigation treatments did not significantly affect total chlorophyll, calcium or magnesium contents in summer or autumn seasons. Emy leaves contained higher total chlorophyll than those of Paulista. In autumn season, dry weight and protein contents were increased by the application of 60% Class A Pan treatment and T.S.S and fiber contents were increased by 100% Class A Pan treatment. In summer season, plant which received 80% Class A Pan produced pods having the highest values of length and diameter, the highest values of protein content was attained by 100 Class A Pan. Pod of Paulista cultivar had higher values of fresh and dry weights, length and diameter compared to those of Emy ones. The fiber and protein contents was higher in cv. Emy in autumn than in Paulista whereas in summer the protein content was higher in cv. Paulista than in cv. Emy. The hightest productivity for both early and total yields were obtained when plants were irrigated with the highest regime (100% Class A Pan treament). Emy cultivar was favourable for autumn season while Paulista cultivar was suitable for summer season. Results on calculated

and actual Kc during autumn and summer seaasons indicated that there were no differences between calculated and actual Kc under irrigation treatments for Emy and Paulesta plants. Water use efficiency was increased as irrigation levels increased.

Snap bean is an important crop in Egypt for local consumption as well as for exportation. This crop is growing in the open field in two main seasons, *i.e.* spring and autumn, using bush type cultivars (Saleh, 1996). Beans are rapidly growing plants and very sensitive to soil water conditions and quality, so yield can suffer greatly from even brief periods of water shortage. High yields depend heavily upon adequate soil moisture during the postbloom stage. The need for high amounts of water during the prebloom stage is more controversial (Halterlein, 1983). Snap bean cultivars showed varied responses to irrigation regimes regarding yield (Mack & Varseveld, 1982; Bonanno & Mack, 1983 and Barbieri & Pascle, 1992) and pod quality (Bonanno & Mack, 1983 and Doorenbos *et al.*, 1986). This work aimed to study the effect of water irrigation levels on the growth, yield, and chemical composition of Paulista and Emy snap bean plants.

Material and Methods

Two experiments were performed in summer and autumn seasons of 1999 and 2000 at El-Bosaily Protected Cultivation Site, Agicultural Research Center west of Rosetta, to investigate the water requirements of green beans under EL-Bosaily conditions. The soil was sandy with pH of 7.89 and Ec of 1.34 mm hos. Two green snap bean cultivars were uesd, *i.e,* Emy (extra fine) and Paulista (fine type). Seeds were sown in hills 25 cm apart on ridges having 50 cm width. Plot area was 23 m^2 (23 × 1). A distance of 150 cm was left between each two irrigation and treatments. Seeds, in summer and autumn season, were sown on 4 and 9 April and on 30 and 28 September in 1999 and 2000, respectively. Low polyethylene tunnels were used in autumn season starting on 25 and 22 November 1999 and 2000, respectively. The experiments were carried out in split plot desgin with three replicates. The irrigation treatments were arranged in the main plots, whereas the cultivars were arranged in the sub plots. All agricultural practices were performed as recommended by Ministry of Agriculture. Lysomter tanks each of 1×1×0.5 m^3 were used. Each lysometer tank was divided into two halfs to grow one cultivar in each half and was used to measure the actual consumption. Each treatment was supplied by a water giger to measure the amount of water used for irrigation which was done by the drip system. Three treatments of irrigation regimes, according to Class A Pan, were used, *i.e.,* 100, 80, 60% Class

A Pan. The data of Class A Pan for EL-Bosaily site expressed in mm / day were obtained from meterological station locted in the site. Calculation of potential evapotranspiration and water consumptive use were made according to the formula of Doorenbos & Pruitt (1977). Water and irrigation requirements were also calculated in autumn and spring seasons in both years. The total amount of water required in summer season were 4796, 3838, and 2927 ℓ day for 100%, 80% and 60% Class A Pan respectivly in 1999 and the corresponding values in 2000 seasons were 2477, 1482 and 1488 ℓ / day, respectivly. Whereas the total amount of water required in autumn season were 1882, 1489 and 1121 ℓ / day for 100 %, 80 % and 60 % Class A Pan, respectivly, in 1999 season, and the corresponding values were 1589, 1255 and 954 ℓ / day, respectivly in 2000 season.

Data recorded

Plant height, number of leaves per plant, total leaf area and total fresh and dry weight of leaves were recorded at the flowering stage. Length, diameter, fresh and dry weight of pods were recorded at the end of season. Early yield in autumn and total yield of green pods per plant and per feddan were recorded in summer and autumn seasons. Total chlorophyll was measured in leaves by using digital chlorophyll meter (model Minolta chlorophyll meter SPAD-501). Total calcium and magnesium were determined in leaves spectormetrically using Phillips PU 9100 Atomic Spectrometer according to Doll & Luces (1973). Total soluble solids and fibers were determined in green pods according to A.O.A.C. (1984). Total protein was determined in green pods on dry weight basis using Micro-Kjeldahle method according to Piper (1947). All data were subjected to statistical analysis according to the procedures " ANOVA " reported by Snedecor & Cochran (1980).

Results and Discussion

Vegetative growth

The application of 100% Class A Pan treatment produced the tallest plants and the highest number of leaves per plant in summer and autumn seasons (Table 1) while leaf area, fresh and dry weight of leaves were not statistically affected by irrigation treatments, except fresh weight of leaves in summer season which was increased by 100% Class A Pan treatment. The obtained results are in agreement with those of EL-Saeid (1981); EL-Saied *et al.* (1983); Kerlous (1997) and EL-Tohamy *et al.* (1999a) who reported that irrigation increased height and leaf number of snap bean plants. It could be concluded from the combined analysis that the highest level of irrigation regime (100% Class A Pan) was the most favourable for stimulating plant growth expressed as plant height and number of

leaves, in both autumn and spring seasons. Leaf area, fresh and dry weight of leaves seemed to increase in the summer season due to irrigation with 100% Class A Pan.

The favourable effect of the highest irrigation regime (100% Class A Pan) on plant growth may be due to increasing the available soil moisture which in turn may increase the abosrption of water and the uptake of the nutritional elements thus causing favourable condition for the physiolegical processes needed for plant growth. The obtained results indicated that neither cultivars nor the interaction between irrigation treatments and cultivars statistically influenced the studied growth features, *i.e.* plant height, number, area, fresh and dry weight of leaves, in summer and autumn seasons, except plant height in summer which was affected by cultivar; Paulista plants were taller than Emy ones.

Chemical components of leaves

The combined analysis showed that irrigation treatments did not significantly affect total chlorophyll, calcium or magnesium contents in summer or autumn seasons (Table 2). Similar results were reported by Ezzo (1998) who found that the effect of irrigation on Ca, Mg of cantaloupe leaves was not statistically significant.

Concerning cultivars, Emy leaves contained higher total chlorophyll than those of Paulista. This effect was not significant in summer season. As for Ca and Mg contents of cultivars, no significant differences were observed between Emy and Paulista leaves. The interaction between irrigation regimes and cultivars did not significantly affect total chlorophyll, Ca or Mg contents indicating that these factors had independent effects on such characters.

Yield and its components

Pod characters

In autumn season, irrigation treatments did not affect fresh weight, length and diameter of green pods, but the dry weight and protein contents were increased by the application of 60% Class A Pan treatment and T.S.S and fiber contents were increased by 100% Class A Pan treatment. EL-Beheidi (1976) found that long and very long irrigation periods increased T.S.S of snap bean pods and Bonanno & Mack (1983) and Doorenbos *et al.* (1986) reported that moisture stress during pod development increased fiber content of snap bean. Whereas, in summer season, plant received 80% Class A Pan treatment produced pods having the highest values of length and diameter. The obtained results are coincided with the findings of Gawish (1992); Kerlous (1997) and EL-Tohamy *et al.* (1999b) who observed that the highest value of pod's length, diameter, weight and volume resulted from plants exposed high irrigation levels. The highest values of protein content was attained by 100% Class A Pan,while T.S.S and fiber contents were not effected by irrigation regimes (Table 3). Similar results were reported by

Wally (1973) who found that T.S.S of broad beans pods were not affected by water regime.

As for the effect of cultivar, pod of Paulista cultivar had higher values of fresh and dry weights, length and diameter compared with Emy pods. The fiber and protein contents was higher in cv. Emy in autumn than in Paulista whereas in summer the protein content was higher in cv. Paulista than in cv. Emy. The obtained results are coincided with those of Mack & Varseveld (1982); Bonanno & Mack (1983) and Nemeskéri (1987). They noticed that there were varietal differences among snap been cultivars in fiber content of pods. The differences in T.S.S content were not significant between the two cultivars.

Regarding the interaction, no significant effects on pod characters were noticed for irrigation treatments for both Emy and Paulista cultivars, except for T.S.S and protein contents, the most favourable treatments for increasing the T.S.S. were Emy cultivar which received 100% Class A Pan and cv. Paulista which received 80% Class A Pan, in autumn. Whereas in summer, the interaction was not statistically significant. As for protein content, green pods of Emy plants irrigated with 60% Class A Pan in autumn had the highest protein values, whereas in summer Emy plants irrigated with 100% Class A Pan and Paulista plants irrigated with 60% Class A Pan produced green pods having the highest protein values.

Early yield

The early yield was determined only in the autumn season because the prevailing environmental conditions provide relatively long harvesting period during this season (Table 4). The highest value of early yield was obtained with 100% Class A Pan treatment, while the lowest value was recorded with 60% Class A Pan one. The differences among 100, 80 and 60% Class A Pan treatments were significant. These results are coineided with those of EL-Beheidi (1976); EL-Saeid (1981); Doorenbos *et al.* (1986) and EL-Tohamy *et al.* (1999b).

The obtained results showed also that cv. Emy produced greater early yield than cv. Paulista. The interaction between irrigation treatments and cultivars was significant. The best treatment was obtained with 100% Class A Pan and cv. Emy which significantly outyield any other interaction treatment.The obtained results are in agreement with those of Mack & Varseveld (1982), Bonanno & Mack (1983) and Barbieri & Pascle (1992) who observed significant differences among snap bean cultivars in their early yields.

TABLE 1. Effect of irrigation regimes on plant growth of snap bean (combined analysis of 1999 and 2000 seasons).

Treatments	Plant height (cm)		Leaf No.		Leaf F. W. (g)		Leaf D. W. (g)		Leaf area (cm^2)	
	autumn	summer	autumn	summer	autumn	summer	autumn	summer	autumn	summer
Irrigation (I)										
60 % of Class A pan	16.6	16.8	11.7	10.5	23.7	21.7	4.6	3.7	859.9	655.2
80 % of Class A pan	15.5	16.0	11.6	10.9	21.5	27.2	4.0	4.6	833.1	781.2
100% of Class A pan	16.9	17.5	13.2	11.9	22.0	29.7	3.9	4.9	786.9	846.2
L.S.D at 5%	0.73	0.92	0.64	0.81	N.S	6.40	N.S	N.S	N.S	N.S
Cultivar (C)										
Emy	16.2	16.0	12.3	10.9	23.7	26.4	4.5	4.5	891.6	754.8
Paulista	16.4	17.5	12.0	11.3	21.0	26.0	3.9	4.3	761.7	766.9
L.S.D. at 5%	N.S	0.75	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Interaction (I × C)										
L.S.D at 5%	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

TABLE 2. Effect of irrigation regimes on chemical components of leaves of snap bean (combined analysis of 1999 and 2000 seasons).

Treatments	Total chlorophyll (%)		Calcium (%)		Magnesium (%)	
	autumn	summer	autumn	summer	autumn	summer
Irrigation (I)						
60 % of Class A Pan	38.6	38.9	0.276	0.358	0.897	0.880
80 % of Class A Pan	39.4	38.6	0.261	0.311	0.953	0.708
100% of Class A Pan	38.5	38.2	0.291	0.346	0.938	0.833
L.S.D at 5 %	N.S	N.S	N.S	N.S	N.S	N.S
Cultivar (C)						
Emy	39.8	39.1	0.288	0.355	0.877	0.842
Paulista	37.9	38.0	0.264	0.323	0.983	0.772
L.S.D at 5 %	1.1	N.S	N.S	N.S	N.S	N.S
Interaction (I × C)						
L.S.D at 5 %	N.S	N.S	N.S	N.S	N.S	N.S

TABLE 3. Effect of irrigation regimes on pod characters of snap bean (combined analysis of 1999 and 2000 seasons).

Treatments	Pod length (cm)		Pod diameter (mm)		Pod F. W. (g)		Pod D. W. (g)		T.S.S (%)		Fibers (%)		Total protein (%)	
	autumn	summer	autumn	summer	autumn	summer	autumn	summer	autumn	summer	autumn	summer	autumn	summer
Irrigation (I)														
60 % of Class A Pan	12.6	12.6	6.0	5.9	30.9	28.4	2.8	3.0	3.5	4.6	10.1	11.8	1.8	2.8
80 % of Class A Pan	12.6	13.1	5.9	6.1	29.6	29.4	2.6	3.1	3.8	4.5	8.9	10.6	0.43	0.43
100% of Class A Pan	12.6	12.4	6.0	6.0	28.9	30.1	2.5	3.3	3.8	4.3	10.0	11.5	0.87	4.1
L.S.D at 5 %	N.S	0.33	N.S	0.14	N.S	N.S	0.20	N.S	0.14	N.S	0.79	N.S	0.40	0.83
Cultivar (C)														
Emy	11.9	11.9	5.3	5.4	22.3	22.7	2.0	2.6	3.7	4.5	10.1	11.1	1.9	1.8
Paulista	13.4	13.5	6.7	6.6	37.3	35.9	3.2	3.7	3.7	4.4	9.3	11.5	0.52	3.1
L.S.D at 5 %	0.30	0.27	0.11	0.12	1.8	1.9	016	042	N.S	N.S	0.22	N.S	0.33	0.68
Interaction (I × C)									*				*	*
L.S.D at 5 %	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	0.20	N.S	N.S	N.S	0.57	1.1

TABLE 4. Effect of irrigation regimes on yield and water use efficiency of snap bean (combined analysis of 1999 and 2000 seasons).

Treatments	Early yield (autumn)		Total yield / plant (gm)		Total yield / Ton / feddan		Water use efficiency (Kg /m^3)	
	per plant (g)	per faddan (ton)	autumn	summer	autumn	summer	autumn	summer
Irrigation (I)								
60 % of Class A pan	37.9	1.9	64.6	52.7	3.3	1.7	7.6	1.6
80 % of Class A pan	45.5	2.3	87.1	76.5	4.4	2.6	7.3	1.8
100% of Class A pan	68.2	3.6	119.9	110.3	6.4	3.5	8.6	2.2
L.S.D at 5%	7.3	0.37	12.3	12.1	0.59	0.64	0.92	0.28
Cultivar (C)								
Emy	55.8	2.9	96.6	71.9	5.1	2.3	8.5	1.7
Paulista	45.2	2.2	84.4	87.8	4.2	2.9	7.1	2.1
L.S.D. at 5%	6.0	0.30	10.0	9.9	048	0.37	0.75	0.23
Interaction (I × C)	*	*						
L.S.D at 5%	10.3	0.53	N.S	N.S	N.S	N.S	N.S	N.S

Total yield

The highest total yield resulted from 100% Class A Pan treatment. While, the lowest total yield was obtained from 60% Class A Pan treatment (Table 4). The differences among the three irrigation treatments were significant in both summer and autumn seasons. These results are coincided with those of EL-Beheidi (1976); EL-Saeid (1981); EL-Saied *et al.* (1983); Doorenbos *et al.* (1986); Barbieri & Pascle (1992); Gawish (1992); Barros & Hanks (1993); Kerlous (1997) and EL-Tohamy *et al.* (1999a). They reported that increasing irrigation levels stimulated the production of snap bean plants.

The hightest productivity for both early and total yields were obtained when plants were irrigated with the highest regime (100% Class A Pan treament). Results on calculated and actual Kc during autumn and summer seasons indicated that there were no differences between calculated and actual Kc under irrigation treatments for Emy and Paulesta plants. Water use efficiency was increased as irrigation levels increased.

Concering cultivars , in autumn season, cv. Emy plans gave higher total yield of green snap bean pods than those of cv. Paulista. Whereas, in summer season, Paulista plants outyield those of Emy plants. In other words, Emy cultivar was favourable for autumn season while Paulista cultivar was suitable for summer season. This might be due to the genetical make up of the two cultivars. The obtained results agree with Mack & Varseveld (1982); Bonanno & Mack (1983) and Barbieri & Pascle (1992) who mentioned that there were significant differences in the productivity of snap bean cultivars.

The interaction between irrigation treatments and cultivars had no significant effect on total yield of snap plants. This indicates that these factors have independent effect on the total yield.

Crop cofficient (Kc)

Results on calculated and actual Kc during autumn and summer seaasons indicated that there no differences between calculated and actual Kc under irrigation treatments for Emy and Paulesta plants. The obtained results indicated that the calculated Kc could be used in calculation of water requirement under these conditions.

Water use efficiency

The highest values of WUE were recorded with 100% Class A Pan treatment in both autumn and summer seasons (Table 4). The WUE values for the two cultivars were significant. In autumn, Emy cv. recorded greater values of WUE

than cv. Paulista. While, in summer season, cv. Paulista showed higher results of WUE than cv. Emy. This migth be attributed to that cv. Emy plants produced higher than yield those of cv. Paulista in autumn and the opposite was true in summer season. The interaction between water treatments and cultivars was not significant in both summer and autumn seasons. These results are in harmony with Barros & Hanks (1993) who showed the WUE increased as irrigation level increased. The obtained results are not in agreement with Gawish (1992) who mentioned that the water use efficiency was increased as irrigation levels decreased. These differences might be due to the prevailing conditions during the growing season and / or due to the tested cultivar.

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استجـــــابة نبـــات الفاصـــوليا للســـرى

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أقيمت تجربتان خلال الموسمين الصيفى والشتوى عامى ١٩٩٩ و٢٠٠٠ بموقع البوصيلى للزراعة المحمية لدراسة الأحتياجات المائية لمحصول الفاصوليا الخضراء تحت ظروف منطقة البوصيلى. وذلك بأستخدام صنفين هما أيــمى (مجموعة القرون الرفيعة جدا) و بوليســتا (مجموعة القرون الرفيعة). وتم أستخدام ثلاث معاملات للرى هى ١٠٠% و٨٠% و٦٠% من حلة البخر طراز أ بأستخدام طريقة الزراعة فى ليزوميترات . وأوضحت النتائج أن المعاملة ١٠٠% من حلة البخر طراز أ قد أدت الى زيادة طول النبات وعدد أوراق النبات خلال الموسمين الصيفى والشتوى. بينما مساحة الأوراق والوزن الطــازج والجاف لم تتأثر بمستويات الرى المختلفة. ما عدا الوزن الطــازج للأوراق خلال الموسم الصيفى حيث أنه يزداد مع المعاملة ١٠٠% من حلة البخر طراز أ. وقد أعطى الصنف بوليســتا زيادة فى طول النبات عن الصنف أيــمى. ولم يتأثر محتوى الأوراق من الكلوروفيل والكالسيوم والماغنسيوم بمعاملات الرى المختلفة فى الموسمين الصيفى و الشتوى. وقد أعطى محتوى الأوراق للصنف أيــمى زيادة فى المحتوى الكلى للكلوروفيل عن الصنف بوليســتا. وخلال الموسم الصيفى أزداد الوزن الجاف للقرون والمحتوى الكلى للبروتين مع المعاملة ٦٠% من حلة البخر طراز أ. فى حين أزداد محتوى المواد الصلبة الذائبة الكلية والألياف مع المعاملة ١٠٠% من حلة البخر طراز أ. وخلال الموسم الصيفى أعطت النباتات التى أستقبلت ٨٠% من حلة البخر طراز أ أعلى القيم بالنســبه لطول وقطر القرن. والمحتوى العالى للبروتين قد تحقق مع المعاملة ١٠٠% من حلة البخر طراز أ. وأظهر الصنف بوليســتا زيادة فى الوزن الطــازج والجاف للقرون وكذلك طول وقطر القرن مقارنة بالصنف أيــمى. وأعطى الصنف أيــمى خلال الموسم الشتوى زيادة فى محتوى البروتين والألياف عن الصنف بوليســتا. فى حين أن محتوى البروتين خلال الموسم الصيفى كان عاليا فى الصنف بوليســتا عن الصنف أيــمى. وقد أعطت النباتات التى رويت بالمعاملة ١٠٠% من حلة البخر طراز أ أعلى محصول مبكر ومحصول كلى. وقد تفوق الصنف أيــمى على بوليســتا فى المحصول فى العروة النيلى بينما تفوق الصنف بوليســتا على الصنف أيــمى فى العروة الصيفية. وأظهرت النتائج أنه لا يوجد فرق معنوى خلال الموسمين بين معامل نمو المحصول المحسوب أو الحقيقى للصنفين أيــمى وبوليســتا. وقد زادت كفاءة أستخدام المياه مع زيادة مستويات الرى.