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GROWTH, YIELD, QUALITY AND WATER USE EFFICIENCY OF PEA *(Pisum sativum L.)* PLANTS AS AFFECTED BY EVAPOTRANSPIRATION (ETo) AND SPRINKLER HEIGHT.

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ABSTRACT: ***A field experiment was carried out during the two successive winter seasons of 2004-2005 and 2005-2006 at the Experimental Farm of Minufiya University in Sadat city, Egypt. The soil was sandy in texture. The aim of this investigation was to study the effect of irrigation treatments and sprinkler height on growth, yield quality and WUE of peas (Pisum sativum L.) variety Lincoln. Results exhibited that increasing irrigation level up to 100% ETo increased vegetative growth (plant height, branches no., leaves area, flowers no. and pods no. / plant, fruit set % as well as dry matter of stems, leaves, pods, roots and total plant)) and green pods and dry seeds yields / fed. Pod length exhibited its highest value when plants were subjected to water deficit (60% ETo) whereas; irrigation at either 80 or 60% ETo had equal effect and showed the lowest pod length values. 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. Generally, installation of sprinklers at 75 cm height produced tallest pea plants and higher leaves area / plant and fruit set %. However, dry matter of stem, leaves, roots, pods and total plant exhibited their highest values when sprinklers were positioned at 50 cm height. Flowers no. /plant was not affected by sprinkler height. The highest values of green pods yield/ fed., dry seeds yield/ fed., and pod length as well as pod weight were attained at 50 and/ or 75 cm sprinkler height. Moreover, the highest values of water use efficiency (WUE) for both green pods and dry seeds yields were detected at 75 cm sprinkler height. It could be concluded under the conditions of the experiment or any other similar conditions that pea plants can be irrigated by 100% and /or 80% ETo with sprinkler height 75 cm for obtaining higher green pods yield/ fed. , dry seeds yield/ fed. and WUE .***

***Key Words**: Pisum sativum, irrigation treatments, sprinkler height, yield, quality.*

INTRODUCTION

Green pea *(Pisum sativum L.)* is one of the important vegetable crops

grown in Egypt. The cultivated area of green peas in Egypt is 61640 feddan in both old and new lands. The productivity of peas green pods is 4.27 t/fed. and the total production from the cultivated area is 262987 tons (statistics of Economic Affairs Sector- Egyptian Ministry of Agriculture and Land Reclamation). Besides increasing the protein content of the meal, peas have contributed to improving the protein quality on diet because peas protein is rich in lysine.

Water is the most important factor limiting horizontal and vertical expansion in the production of different crops. Crop yield and quality are affected by available water in the soil. It is highly desirable to obtain higher yield using the least possible quality of water. Increasing number of irrigations, levels of field capacity, irrigation amounts, pan evaporation ratios and/ or potential evapotranspiration (ETo) up to the maximum level increased growth parameters; i.e. plant height, number of branches per plant, leaf area, total plant dry matter, number of flowers and fruit setting percentage (Fatthallah and Gawish, 1997 & Mahmoud, 2000 on peas, and Abdel-Mawgoud, 2006 & El-Shawadfy, 2008 on beans).

Vegetable plants grown under the highest levels of water supply gave the highest records of green pods yield and/ or dry seeds yield, while plants grown under the low irrigation levels showed the lowest values in the same regard. (Imtiyaz *et al*., 2000; Mahmoud, 2000 ; Mohsen and El-Adl, 2000 and Nirmal, *et al*. 2007 all on peas; Metin *et al*., 2005 ; Erdem *et al*., 2006 and El-Shawadfy, 2008 all on beans.

On the other hand, Fatthallah and Gawish (1997) demonstrated that cowpea yield increased by increasing irrigation level up to 60% of field capacity and then declined by the more high irrigation levels, 75 and 90% of field capacity.

Concerning the influence of irrigation on water use efficiency (WUE), Mahmoud (2000) on peas; Mohsen and El-Adl (2000) on peas; Ragheb *et al*. (2000) on faba bean and Metin *et al*. (2005) on beans, revealed that WUE in the different vegetable plants was higher under the higher or medium irrigation level while the lower irrigation level gave the lowest values of water use efficiency.

The present investigation aimed to realize the following:

Study the effect of changing irrigation water application level and riser height on growth characters, yield and its quality and water use efficiency of peas crop.

Determine the appropriate water requirements for peas plants grown in the new reclaimed soils, and response of vegetable crops to be irrigated under sprinkler irrigation system.

MATERIALS AND METHODS

A field experiment was carried out during the two successive winter seasons of 2004-2005 and 2005-2006 at the Experimental Farm of Minufiya University, Sadat city, Egypt. The aim of this experiment was to study the effect of irrigation treatments and sprinkler height on growth, yield and quality of peas (*Pisum sativum L.).* Lincoln pea variety was used as an experimental material in this study. Sowing took place on December 3rd and 20th in the first and second experimental seasons, respectively. Plants were sown in rows 70 cm apart and hills were spaced 10 - 15 cm apart. Thinning was practiced before the first irrigation to secure two plants/ hill. Green pods were picked four times.

Soil samples were taken from different depths of the soil profile to determine the physical and chemical properties of the soil. In addition, samples from irrigation water source were taken for chemical analysis and hydro-physical properties were carried out according to the method described by Klute & Dirksen (1986). Field capacity (F.C.) and permanent wilting point (P.W.P.) were determined according to Black (1965). Data are shown in Tables (1 & 2).

Table (1): Some Physical and chemical properties of soil, at Sadat City, Minufiya, average of 2004-2005 and 2005-2006 seasons.

Depth cm	Mechanical analysis %			Soil classification	pH	Field capacity %	Wilting point %	Bulk density g/ cm3
	Clay	Silt	Sand					
0-15	0.60	5.35	94.05	Sandy	8.1	13.0	5	1.50
15-30	0.75	6.50	92.75	Sandy	8.1	11.5	5	1.45
30-45	0.80	8.00	91.20	Sandy	7.9	13.6	5	1.51

Table (2): Some chemical analysis of irrigation water, at Sadat City, Minufiya, average of 2004-2005 and 2005-2006 seasons.

EC dS/m	pH	Soluble cations (meq/l)				Soluble anions (meq/l)	
		Ca++	Mg++	Na+	K+	HCO3-	SO4- -
0.48	7.5	2.2	1.8	1.9	0.1	4.0	2.0

Experimental irrigation system

Sprinkler irrigation system was constructed to irrigate pea plants, and installed in the experimental site with 3 heights of risers (50, 75 and 100 cm).

Water regime treatments.

Three water application rates were applied for irrigating pea plants which were: 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 Badr city, El-Behera Governorate, using the method described by (FAO, 1991). Irrigation treatments were practiced after the first irrigation. Irrigation was withheld after the last fruit picking. The other agricultural practices, except the studied ones, were carried out as usually done in the district. The amount of irrigation water for green pea was applied by flow meter. The value of crop coefficient (kc) was taken from literature and the amount of water applied in each irrigation was calculated as follows:

Etc= ETo . Kc …….. (1)
Where, ETo is the potential evapotranspiration in the experimental site.

Irrigation water amounts for pea crop throughout the two growing seasons are presented in Table (3).

Table (3): Seasonal, daily water consumptive use (W.C.U.) and water requirements as affected by Sprinkler height and irrigation treatments during two growth seasons.

Variables / Treatments		Irrigation period, day		No. of irrigations/ season		Water Consumption m3/fed. /season		Water Consumption m3/fed. /day		* Water Requirements m3/fed. /season	
Sprinkler height	ETo	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2	S 1	S 2
50	100 %	98	95	28	30	1328	1139	13.55	11.99	1388	1199
	80 %	98	95	28	30	1064	920	10.86	9.68	1124	980
	60 %	98	95	28	30	796	706	8.12	7.43	856	766
75	100 %	98	95	28	30	1328	1139	13.55	11.99	1388	1199
	80 %	98	95	28	30	1064	920	10.86	9.68	1124	980
	60 %	98	95	28	30	796	706	8.12	7.43	856	766
100	100 %	98	95	28	30	1328	1139	13.55	11.99	1388	1199
	80 %	98	95	28	30	1064	920	10.86	9.68	1124	980
	60 %	98	95	28	30	796	706	8.12	7.43	856	766

Treatments:

Field experiments were carried out under the variation of two basic factors which were:

Water application rate with three levels (100 %, 80 % and 60 % of ETo).

Height of riser attached with the sprinkler with three levels (50, 75 and 100 cm) form the ground surface.Therefore the total experimental area included 9 treatments, and each treatment was replicated three times. The experiment contained 27 experimental plots.

Fertilizer program

Fertilizer requirements of pea crop were: 30 m^3 of organic manure/ fed., 100 kg/ fed. of calcium super phosphate (15.5 % P2O5), 50 kg/ fed. of ammonium sulphate (20.5 % N),50 kg/ fed. of potassium sulphate (48 % K2O) and 50 kg/ fed. agricultural sulfur which were added during the seed bed preparation. The other doses from the different fertilizers after sowing were added according to recommendations of Horticulture Research Institute, ARC, Ministry of Agriculture and Land Reclamation.

Experimental design

The experimental design used was split plot one with three replications. The water treatments and sprinkler height were assigned in the main and sub main plots, respectively.

Measurements and calculations

One vegetative sample of 3 plants was taken in the last pod collection for the two growing seasons. The following characters were measured:

a - Growth:

1) Plant height (cm).
2) Number of branches / plant.
3) Number of pods / plant.
4) Area of leaves / plant (cm2).
5) Dry weight of stem (g).
6) Dry weight of leaves (g).
7) Dry weight of roots (g).
8) Dry weight of pods (g).
9) Total plant dry matter (g).
10) Number of flowers/ plant.
11) Fruit set percent.

b- Pod quality characters:

1) Pod length. (mm).
2) Pod thickness. (mm).
3) Pod weight. (g).

4) Number of seeds / pod.

c- Total Green pods yield: yields of the different collections were summed together to estimate the total green pods yield.

d- Dry seeds yield

e- Water use efficiencies:

Water use efficiency is an indicator of effectiveness use of irrigation unit for increasing crop yield. Water use efficiencies of green pods and dry seed yields were calculated from the following equations:

WUE of green pod yield = Total green pod yield (kg/fed.)/Total applied irrigation water (m3/fed.)

WUE of dry seed yield = Dry seed yield (kg/ fed.)/Total applied irrigation water (m3/ fed.)

Statistical analysis:-

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

RESULTS And DISCUSSION

1- Effect of irrigation regime

a- Vegetative growth

It is clear from Tables (4 and 5) that in both 2004-2005 and 2005-2006 growth seasons, plant height, branches no., leaves area, flowers no. and pods no. / plant, fruit set % as well as dry matter of stems, leaves; pods and total plant were significantly increased by increasing irrigation level up to 100% Eto. Moreover, the lowest values in the aforementioned characters were exhibited when plants were exposed to water stress (60% Eto). With regard to seeds no./ pod, it is clear that the differences between irrigation levels were not significant in both seasons.

Our results regarding plant height are in accordance with those obtained by Baswana and Legha (1995) and Mahmoud (2000) on peas; Abdel-Mawgoud (2006) on beans and El-Shawadfy (2008) also on beans, who stated that plant height was strongly influenced by increasing irrigation up to the maximum level.

Results could be explained as a result of enhancing cell division and enlargement which need more water supplies (Hammad, 1991).

The results previously mentioned concerning number of branches per plant are in harmony with those obtained by Mahmoud (2000) on peas; and El-Shawadfy (2008) on beans, who found that number of branches per plant in peas and/or beans was significantly increased by increasing irrigation rate.

Table 4

Table 5

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.

Also, our findings concerning leaf area are in agreement with those of Fatthallah and Gawish (1997) and Mahmoud (2000) on peas; and El-Shawadfy (2008) on beans, who indicated that increasing irrigation levels up to the maximum level gave the highest values of leaf area.

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 effect of high or low level of irrigation on total plant dry matter which was detected in the present investigation is in accordance with the results of Fatthallah and Gawish (1997) and Mahmoud (2000) on peas and El-Shawadfy (2008) on beans, who found that higher levels of irrigation increased dry matter production markedly than lower levels.

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 pea 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.

Obtained results regarding number of flowers and fruit setting percentage are in agreement with those detected by Hammad (1991) on beans and Mahmoud (2000) on peas, who reported that the number of flowers and fruit set increased by increasing the amount of water supply.

Results may be explained as increasing water supply gave the opportunity to more absorbing nutrients, factor that may positively affect flowering and fruit set.

An explanation was done by El-Beltagy *et al*. (1984) who showed that the level of auxins and gibberlin like substances increased in pepper plants at either the flowering and /or fruiting stages as the percentage of field capacity increased up to 90%. However, Darbyshire (1971) told that the activity of indole acetic acid oxidase was shown to increase following a period of water stress which in turn decreased auxins level in pea tissues.

b- Productivity, pod quality criteria and WUE

It is clear from Tables (6 and 7) that there are significant differences due to variation of irrigation rates in green pods and dry seeds yields kg / fed. and WUE for both criteria in the two experimental seasons of 2004-2005 and 2005-2006 as well as pod length in the first season only. However, pod thickness and pod weight in both growing seasons in addition to pod length in the second season did not show any significant response to various water supply levels. In the two growing seasons, it is obvious from data that the highest values of green pods and dry seeds yields kg / fed. were achieved by irrigating pea plants by 100% ETo. Moreover, irrigation at 80% ETo led to obtaining significantly medium values whereas, 60% ETo level of irrigation showed the lowest significant values in the same concern. In the first season, increases in green pods and dry seeds yields kg / fed. were 137 % and 248%, respectively for 100% ETo comparing with 60% ETo (water stress treatment). Whereas, in the second season the increases reached to 101% and 99.7% in the two mentioned characters for 100% ETo in comparison with 60% Eto.

On the contrary, in the first season of the experiment pod length showed a different trend where it exhibited its highest significant value when plants were subjected to water deficit (60% ETo). While, irrigation at either 80 or 60% ETo had equal effect and showed the lowest pod length values.

It is worthy to mention that in the two seasons of experimentation, WUE for green pods yield exhibited the highest significant values when pea plants were irrigated at 80% ETo, 100% ETo ranked second whereas 60% Eto ranked third in the same concern. The same trend was observed for WUE of dry seeds yield in the first growth season, however in the second season, the highest significant values were attained when pea plants were irrigated at 100% ETo.

The results reported here in this investigation concerning green pods and dry seeds yields coincided with those previously obtained by Imtiyaz *et al*. (2000) and Nirmal *et al*. (2007) on peas; Metin *et al*. (2005); Erdem *et al*. (2006) and El-Shawadfy (2008) on beans, who noticed that plants grown under the highest levels of water supply gave the highest records of green pods yield and/ or dry seeds yield, while plants grown under the low irrigation levels showed the lowest values in the same regard.

The increment in total yield of green pods and dry seeds yield could be mainly explained as a result of increasing number of pods/plant. Besides, the sufficient supply of water may activate metabolic processes within plants, especially those which affect productivity (Mahmoud, 2000)

On the other hand, Fatthallah and Gawish (1997) demonstrated that cowpea yield increased by increasing irrigation level up to 60% of field capacity and then declined by the more high irrigation levels. 75 and 90% of field capacity.

Table 6, 7

The detrimental effect of water stress on total yield of dry seeds and its components 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 (Hsiao and Acevedo, 1974), which in turn may negatively affect dry seeds yield.

Our results regarding water use efficiency (WUE) were supported by other investigators among them are; Mahmoud (2000) and Mohsen and El-Adl (2000) on peas; and Metin *et al*. (2005) on beans and Ragheb *et al*. (2000) on faba bean, who showed that WUE in the different vegetable plants was higher under the higher or medium irrigation level while the lower irrigation level gave the lowest values of water use efficiency.

2- Effect of sprinkler height

a- Vegetative growth

Growth parameters of pea plants as affected by sprinkler height in the two experimental seasons of 2004-2005 and 2005-2006 are exhibited in Tables (4, 5). Data showed that in both seasons of growth; plant height and leaves area/ plant as well as dry matter of stems, leaves, roots, pods and total plant were significantly affected by changing sprinkler height.

Moreover, the other studied growth criteria exhibited a different significant response to sprinkler height which varied also from one season to another. It is worthy to mention that the significantly tallest pea plants were detected when sprinklers were installed at either 50 or 75 cm height in both growing seasons. On the contrary, the shortest plants were obtained at 100 cm sprinkler height. However, leaves area / plant showed another trend, where the highest significant values were expressed by 75 and 100 cm sprinkler height in the first and second experimental season, respectively. Flowers no./ plant was not significantly affected by sprinkler height in both seasons. However, fruit set showed the highest significant values when using either 75 or 100 cm sprinkler height in the first growing season only. A very obvious trend was attained regarding the influence of sprinkler height on the dry matter accumulation of the different pea plant parts or the whole plant indicating that the highest significant values of stem, leaves, roots, pods and total plant dry matter were obtained when sprinklers were positioned at 50 cm height in the two seasons of the trial.

b- Productivity, pod quality criteria and WUE

Green pods yield/ fed; dry seeds yield/ fed.; pod quality criteria and WUE for both green pods and dry seeds yields of pea plants in the two experimental seasons of 2004-2005 and 2005-2006 are exhibited in Tables (6, 7). Data exhibited that all studied parameters were significantly influenced by differing sprinkler height in both seasons except for pod thickness in the first season as well as pod length and weight in the second season. It is noteworthy to mention that the trend regarding the effect of sprinkler height

on the different pod yield and quality parameters was quite different from one season to another. Generally, in the first season the highest significant values of green pods yield/ fed., dry seeds yield/ fed., and pod length as well as pod weight were attained at 75 cm sprinkler height, whereas the lowest values in the same regard were exhibited at 50 cm height. On the contrary, in the second season the highest significant values of green pods yield, dry seeds yield and pod thickness were obtained at 50 cm sprinkler height.

It is important to conclude that in the first season, the increase in green pods yield/ fed. was 19.3% for 75 cm sprinkler height comparing with 50 cm height which showed the lowest value. Whereas, the increase in dry seeds yield/ fed. amounted to 32.8% for 75 cm sprinkler height comparing with 100 cm height.

However, in the second season the increase in green pods yield/ fed. was 12.5% for 50 cm sprinkler height comparing with 100 cm height which showed the lowest value. Moreover, the increase in dry seeds yield/ fed. amounted to 11.1% for 75 cm sprinkler height comparing with 100 cm height. Regarding the influence of sprinkler height on WUE for dry seeds yields, it was observed that the highest significant values for this parameter were detected at 75 cm sprinkler height in both seasons. Moreover, WUE for green pods yield exhibited the same trend in the first season.

3- Effect of interaction

a- Vegetative growth

Significant differences due to interaction were attained in; plant height, leaves area/ plant, dry matter of roots, pods and total plant in both experimental seasons, dry matter of stems in the first season as well as seeds no./ pod and dry matter of leaves in the second experimental season. Other characters did not show any significant response due to interaction (Tables 8, 9).

Data in Table (8) demonstrated that in the first season no obvious trend could be detected regarding the highest and lowest interaction values of the significantly affected criteria. It is worthy to mention that the highest significant interaction values of plant height and dry matter of pods and total plant were attained when pea plants were irrigated by 100% ETo and sprinkler height was 50 cm. However, the lowest significant values in the same regard were exhibited by the interaction 60% ETo X 100 cm sprinkler height. Moreover, the highest significant interaction valuesof leaves area/ plant and dry matter accumulation in stems were shown by 100% ETo X 75 cm sprinkler height. In addition, the highest significant interaction value of roots dry matter was shown by 60% ETo X 50 cm sprinkler height. Results of the second season (Table, 9) showed somewhat similar trend concerning the interaction influence on most of the studied growth parameters indicating that plant height and dry matter of leaves, roots, pods and total plant exhibited their highest significant values when pea plants were irrigated by 100% ETo and sprinkler height was 50 cm.

Table 8

Table 9

On the contrary the lowest significant values of the same parameters were detected by the interaction 60% ETo X 100 cm sprinkler height. Moreover, leaves area/ plant and No. of seeds/ pod showed another interaction trend.

b- Productivity, pod quality criteria and WUE

Effect of interaction between irrigation regimes and sprinkler height on productivity, pod quality criteria and WUE for both green pods and dry seeds yields of pea plants is exhibited in Tables (10 and 11) It could be concluded that in both growth seasons, the interaction influence was significant on green pods yield/ fed., dry seeds yield/ fed., pod length and WUE for both green pods and dry seeds yields of pea plants, whereas pod thickness and pod weight were not significantly affected by the interaction. A quite similar trend of the interaction in both seasons was obtained in green pods yield/ fed. indicating that this parameter showed its highest significant value when pea plants were irrigated by 100% ETo and sprinkler height was 100 cm. However, the highest significant value of dry seeds yield/ fed. was obtained at 100 % ETo X 75 cm sprinkler height in both seasons. Moreover, the aforementioned two characters showed their lowest interaction values at 60% ETo X 100cm sprinkler height. The effect of interaction on pod length did not show significantly obvious trend and was different from one season to another. Concerning the interaction effect on WUE for both green pods and dry seeds yields of pea plants in the first season of growth, it was noticed that the two criteria showed the same trend indicating that the highest significant values of interaction were obtained at 80% ETo and 75 cm sprinkler height. However, the lowest values in the same regard were detected at 60% ETo and 100 cm sprinkler height. In the second season, there was another trend where WUE of green pods showed its highest significant values in the interaction 80% ETo X 50 cm height. However, the highest significant values for WUE of dry seeds were obtained at 100% ETo X 75 cm sprinkler height. Moreover, the lowest significant values for both parameters were attained by the interaction 60% ETo x 100 cm sprinkler height.

4- Water relations

Data in Table (3) indicated that the length of irrigation period differed from one season to another, where it was 98 days and 95 days for the first and second growth season, respectively. Moreover, number of irrigation was 28 and 30 for the first and second season of investigation, respectively. Regarding total water consumption (m3/fed./season), data in table (3.4) exhibited that it varied from one season to another according to meteorological components. In addition, total water consumption also varied among application rates, where it was 1328, 1046, and 796 (m3/fed./season) in the first season and 1139,920 and 706 (m3/fed./season) in the second season, for 100%, 80%, 60% ETo, respectively.

Table 10

Table 11

Water consumption (m3/fed./season)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.

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النمو، والمحصول، والجودة وكفاءة استعمال الماء لنباتات البسلة وتأثرها بالبخر نتح المرجعى (ETo) وارتفاع الرشاش

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الملخص العربي

أجريت هذه الدراسة بالمزرعة التجريبية لجامعة المنوفية بمدينة السادات، بمصر، وكانت التربة رملية القوام، وهدف هذا البحث لدراسة تأثير معاملات الرى وارتفاع الرشاش على النمو، والمحصول، وجودته، وكفاءة استعمال الماء لنباتات البسلة صنف لنكولن.

وقد أظهرت النتائج مايلى:

- أن زيادة معدل الرى حتى ١٠٠% من البخرنتح المرجعى (ETo) قد أدت الى زيادة النمو الخضرى(ارتفاع النبات ، وعدد الأفرع/ نبات ، ومساحة أوراق النبات ، وعدد الأزهار والقرون للنبات ، والنسبة المئوية لعقد الثمار ، وكذلك المادة الجافة لكل من الساق ، والأوراق ، والقرون ، والجذور ، والنبات الكلى) ومحصول القرون الخضراء للفدان ، وكذلك محصول البذور الجافة للفدان.
- أعطت صفة طول القرن أعلى القيم عند تعرض النباتات لنقص الماء(٦٠%بخرنتح) بينما وجد أن رى النباتات سواء بمعدل ٦٠ أو ٨٠% بخر نتح كان متساوى وأعطى أقل طول للقرون.
- كانت نباتات البسلة أعلى كفاءة فى استخدام الماء سواء لمحصول القرون الخضراء أو البذور الجافة عند الرى بمعدل ٨٠% بخر نتح وأقل كفاءة كانت عند الرى بمعدل ٦٠% بخر نتح.

- **وبصفة عامة وجد أن تركيب الرشاشات على ارتفاع ٧٥ سم من سطح الأرض أدى الى الحصول على أطول النباتات وأعلى مساحة لأوراق النبات وأعلى نسبة لعقد الثمار، بينما لم يتأثر عدد الأزهار للنبات بارتفاع الرشاش.**
- **وجد أن أعلى محصول للقرون الخضراء والبذور الجافة للفدان وأعلى طول ووزن للقرن أمكن الحصول عليه عند ارتفاع رشاش ٥٠ أو ٧٥ سم.**
- **أعلى كفاءة فى استعمال الماء سواء لمحصول القرون الخضراء أو البذور الجافة أمكن الحصول عليها عندما كان ارتفاع الرشاش ٧٥ سم.**

ومن النتائج المتحصل عليها سابقا يمكن التوصية تحت ظروف التجربة أو أية ظروف أخرى مشابهة ، بزراعة أصناف البسلة متوسطة الطول ، مع ريها بمعدل ١٠٠% من البخرنتح المرجعي والذي يعادل ١٢٩٩م٣ / فدان / موسم ، مع استخدام نظام الرى بالرش وتركيب الرشاشات على ارتفاع ٧٥ سم ، وذلك لتفوق النباتات مع المعاملات السابقة في صفات النمو المختلفة ، ومحصول القرون الخضراء / فدان ، ومحصول البذور الجافة / فدان ، وكذلك لزيادة كفاءة استعمال الماء WUE لصفتى المحصول السابقتين.

التوصيات :

ومن النتائج المتحصل عليها سابقا يمكن التوصية تحت ظروف التجربة أو أية ظروف أخرى مشابهة ، بزراعة أصناف البسلة متوسطة الطول ، مع ريها بمعدل ١٠٠% من البخرنتح المرجعي والذي يعادل ١٢٩٩م٣ / فدان / موسم ، مع استخدام نظام الرى بالرش وتركيب الرشاشات على ارتفاع ٧٥ سم ، وذلك لتفوق النباتات مع المعاملات السابقة في صفات النمو المختلفة ، ومحصول القرون الخضراء / فدان ، ومحصول البذور الجافة / فدان ، وكذلك لزيادة كفاءة استعمال الماء WUE لصفتى المحصول السابقتين .

Table (4): Effect of water application rate and riser height on vegetative growth characters of pea plants in El-Sadat - Minufiya during 2004-2005 season.

Tested factors	Growth characters							Dry weight (g)/Plant				
Variables / Treatments	Plant height (cm)	Branches No./ plant	Leaves area (cm^2)/plant	Flowers No./ plant	Fruit set %	Pods No./ plant	Seeds No./ pod	Stems	Leaves	Roots	Pods	Total plant
100% ETo	55.4 a	4.89 a	2771 a	20.2 a	86.0 a	17.0 a	6.40	16.6 a	9.3 a	1.0 b	26.8 a	56.9 a
80% ETo	45.0 b	5.00 a	2627 b	11.3 b	79.3 b	9.0 b	5.93	11.9 b	8.7 a	1.0 b	28.4 a	50.2 b
60% ETo	41.8 b	3.89 b	2268 c	8.8 c	74.7 c	6.7 c	6.60	7.3 c	6.2 b	1.4 a	13.0 b	32.0 c
H1= 50cm	50.6 a	5.22	2579 b	12.4	76.9 b	9.7	5.76 b	11.9 ab	9.7 a	1.4 a	27.2 a	51.9 a
H1= 75 cm	49.0 a	4.22	2644 a	14.1	82.5 a	11.9	6.64 a	13.7 a	7.3 b	1.1 a	23.4 b	49.1 b
H1=100cm	42.7 b	4.33	2443 c	13.8	80.6 a	11.1	6.53 a	10.2 b	7.2 b	0.8 b	17.8 c	38.0 c

Table (5): Effect of water application rate and riser height on vegetative growth characters of pea plants in El-Sadat - Minufiya during 2005-2006 season.

Tested factors	Growth characters														Dry weight (g)/Plant									
Variables / Treatments	Plant height (cm)		Branches No./ plant		Leaves area (cm^2)/plant		Flowers No./ plant		Fruit set %		Pods No./ plant		Seeds No./ pod		Stems		Leaves		Roots		Pods		Total plant	
100% ETo	52.1	a	7.78	a	3096	a	18.8	a	82.8	a	15.3	a	6.82		15.2	a	11.8	a	1.5	a	22.3	a	51.6	a
80% ETo	44.0	b	7.67	a	2664	b	12.5	b	77.1	b	9.7	b	6.36		11.3	b	8.3	b	1.1	b	14.3	b	35.5	b
60% ETo	34.0	c	5.89	b	2025	c	8.7	c	73.6	c	6.6	c	6.78		7.4	c	5.9	c	1.1	b	8.3	c	22.8	c
H1= 50cm	45.6	a	7.33		2540	b	11.7		76.6		9.2	b	6.58		12.7	a	9.4	a	1.5	a	18.5	a	43.6	a
H1= 75 cm	44.9	a	6.81		2597	ab	14.9		80.5		12.1	a	6.84		11.9	a	8.7	ab	1.1	b	13.6	b	35.2	b
H1=100cm	39.7	b	7.44		2647	a	13.4		76.5		10.2	ab	6.53		9.3	b	7.9	b	1.0	b	12.9	b	31.1	c

Table (6): Effect of water application rate and riser height on yield, pod quality characters and WUE of pea plants in El-Sadat - Minufiya during 2004-2005 season.

Variables / Treatments	Green pods yield (kg/ fed.)		Dry seeds yield (kg / fed.)		Pod length (mm)		Pod thickness (mm)		Pod weight (g)		WUE(kg/ m3) for green pods yield		WUE(kg/ m3) for dry seeds yield	
100% ETo	3852	a	710	a	70.5	b	8.84		4.36		2.1544	b	0.3972	b
80% ETo	2866	b	500	b	70.4	b	9.12		4.21		2.5501	a	0.4453	a
60% ETo	1624	c	204	c	74.7	a	8.90		4.75		1.8977	c	0.2382	c
H1= 50cm	2545	c	435	b	67.6	c	9.12		4.02	b	2.0345	c	0.3337	b
H1= 75 cm	3036	a	559	a	75.5	a	8.80		4.55	a	2.4589	a	0.4349	a
H1=100cm	2762	b	421	b	72.5	b	8.94		4.75	a	2.1088	b	0.3122	b

Table (7): Effect of water application rate and riser height on yield, pod quality characters and WUE of pea plants in El-Sadat - Minufiya during 2005-2006 season.

Variables / Treatments	Green pods yield (kg/ fed.)		Dry seeds yield (kg / fed.)		Pod length (mm)		Pod thickness (mm)		Pod weight (g)		WUE(kg/ m3) for green pods yield		WUE(kg/ m3) for dry seeds yield	
100% ETo	3816	a	715	a	80.8		9.26		3.73		3.1829	b	0.5964	a
80% ETo	3292	b	448	b	76.1		9.32		3.38		3.3587	a	0.4569	b
60% ETo	1899	c	358	c	74.9		9.22		3.22		2.4789	c	0.4677	b
H1= 50cm	3141	a	522	a	76.6		9.66	a	3.38		3.1946	a	0.5249	a
H1= 75 cm	3073	b	529	a	76.0		8.85	b	3.40		3.1169	b	0.5260	a
H1=100cm	2792	c	470	b	79.3		9.29	ab	3.54		2.7090	c	0.4701	b

Table (8): Effect of interaction between level of water application rate and riser height on vegetative growth characters of pea plants in El-Sadat - Minufiya during 2004-2005 season.

Tested factors		Growth characters																							
Variables / Treatments		Plant height (cm)		Branches No./ plant		Leaves area (cm^2)/Plant		Flowers No./ plant		Fruit set %		Pods No./ plant		Seeds No./ pod		Dry weight (g)/Plant: Stems		Leaves		Roots		Pods		Total plant	
100 % ETo	H1= 50cm	62.0	a	5.67		2673	bc	16.7		82.4		13.8		6.07		16.3	b	12.3		1.5	ab	33.8	a	66.8	a
	H2= 75 m	50.0	bc	4.67		2989	a	21.7		87.1		18.9		6.13		20.8	a	8.3		0.9	c	29.1	b	58.8	b
	H3= 100 cm	54.3	b	4.33		2649	bc	22.3		88.5		18.4		7.00		12.7	c	7.3		0.7	c	17.5	c	45.0	d
80% ETo	H1= 50 cm	44.7	cd	5.33		2561	cd	11.7		76.4		8.9		5.20		13.3	bc	10.3		0.9	c	27.5	b	51.4	c
	H2= 75 cm	50.7	bc	4.67		2633	bc	10.7		83.1		8.9		6.67		12.2	c	7.5		1.1	bc	29.8	b	50.5	c
	H3= 100 cm	39.7	de	5.00		2688	b	11.7		78.3		9.1		5.93		10.2	cd	8.2		1.0	c	28.0	b	48.7	cd
60% ETo	H1= 50 cm	45.0	cd	4.67		2503	d	9.0		71.9		6.4		6.00		5.9	e	6.4		1.7	a	20.1	c	37.5	e
	H2= 75 cm	46.3	cd	3.33		2309	e	10.0		77.4		7.9		7.13		8.0	de	6.1		1.5	ab	11.2	d	38.1	e
	H3= 100 cm	34.0	e	3.67		1991	f	7.3		74.9		5.7		6.67		7.9	de	6.2		0.9	c	7.7	e	20.4	f

Table (9): Effect of interaction between level of water application rate and riser height on vegetative growth characters of pea plants in El-Sadat - Minufiya during 2004-2005 season.

Tested factors		Growth characters												Dry weight (g)/Plant									
Variables / Treatments		Plant height (cm)		Branches No./ plant		Leaves area (cm^2)/Plant		Flowers No./ plant		Fruit set %		Pods No./ plant		Seeds No./ pod		Stems		Leaves		Roots		Pods		Total plant	
100% ETo	H1= 50 cm	56.3	a	7.78		2741	c	13.8		83.0		11.4		7.33	a	16.6		13.3	a	2.3	a	25.2	a	60.1	a
	H2= 75 cm	45.7	bc	7.44		2970	b	21.4		84.5		18.1		5.87	c	16.2		11.3	b	1.2	b	22.6	ab	50.9	b
	H3= 100 cm	54.3	a	8.22		3576	a	21.1		80.9		16.2		7.27	a	12.7		10.9	b	1.0	b	19.2	c	43.9	c
80% ETo	H1= 50 cm	44.7	bc	7.78		2591	d	13.2		72.0		9.6		5.93	c	13.6		8.4	cd	1.0	b	20.4	bc	45.0	c
	H2= 75 cm	48.0	b	7.56		2915	b	12.3		80.8		10.0		7.13	ab	11.5		7.8	cd	1.1	b	10.4	de	30.7	d
	H3= 100 cm	39.3	de	8.00		2486	e	12.0		78.7		9.4		6.00	c	8.9		8.6	c	1.1	b	12.3	d	30.9	d
60% ETo	H1= 50 cm	35.7	e	6.44		2289	f	8.2		74.7		6.6		6.47	bc	8.0		6.6	d	1.1	b	10.0	de	25.6	de
	H2= 75 cm	41.0	cd	5.44		1908	g	10.9		76.2		8.2		7.53	a	8.1		7.0	cd	1.1	b	7.8	ef	24.1	ef
	H3=100 cm	25.3	f	6.11		1879	g	7.0		69.8		4.9		6.33	c	6.2		4.2	e	1.0	b	7.2	f	18.6	f

Table (10): Effect of interaction between level of water application rate and riser height on yield, pod quality characters and WUE of pea plants in El-Sadat - Minufiya during 2004-2005 season.

Variables / Treatments		Green pods yield (kg/ fed.)		Dry seeds yield (kg / fed.)		Pod length (mm)		Pod thickness (mm)		Pod weight (g)		WUE(kg/ m3) for green pods yield		WUE(kg/ m3) for dry seeds yield	
100% Eto	H1= 50 cm	3619	c	680	b	68.6	cd	9.09		4.00		2.0243	d	0.3807	bc
	H2= 75 cm	3649	c	749	a	75.7	ab	8.63		4.40		2.0410	d	0.4190	b
	H3= 100 cm	4288	a	701	ab	67.3	de	8.81		4.67		2.3981	b	0.3920	bc
80% Eto	H1= 50 cm	2199	e	390	c	63.4	e	9.29		4.02		1.9568	e	0.3463	c
	H2= 75 cm	3739	b	706	ab	74.2	ab	9.19		4.49		3.3268	a	0.6287	a
	H3= 100 cm	2660	d	406	c	73.5	abc	8.87		4.13		2.3666	b	0.3610	c
60% Eto	H1= 50 cm	1817	f	234	d	70.7	bcd	9.00		4.04		2.1224	c	0.2740	d
	H2= 75 cm	1720	g	220	d	76.8	a	8.57		4.76		2.0088	de	0.2570	d
	H3= 100 cm	1337	h	157	e	76.8	a	9.15		5.45		1.5618	f	0.1837	e

Table (11): Effect of interaction between level of water application rate and riser height on yield, pod quality characters and WUE of pea plants in El-Sadat - Minufiya during 2005-2006 season.

Treatments	Variables	Green pods yield (kg/ fed.)		Dry seeds yield (kg / fed.)		Pod length (mm)		Pod thickness (mm)		Pod weight (g)		WUE(kg/ m3) for green pods yield		WUE(kg/ m3) for dry seeds yield	
100% Eto	H1 = 50 cm	3610	b	713	b	78.1	b	9.87		3.65		3.0110	c	0.5947	b
	H2 = 75 cm	3606	b	785	a	78.6	b	8.73		3.51		3.0075	c	0.6543	a
	H3 = 100cm	4233	a	648	c	85.7	a	9.19		4.02		3.5301	b	0.5403	c
80% Eto	H1 = 50 cm	3569	b	467	d	74.1	bc	9.56		3.20		3.6415	a	0.4770	de
	H2 = 75 cm	3454	c	438	d	77.9	b	9.13		3.33		3.5241	b	0.4473	ef
	H3 = 100cm	2852	d	437	d	76.4	bc	9.28		3.61		2.9105	cd	0.4463	ef
60% Eto	H1 = 50 cm	2245	e	385	e	77.6	b	9.56		3.30		2.9313	cd	0.5030	cd
	H2 = 75 cm	2159	e	365	ef	71.4	c	8.70		3.37		2.8191	d	0.4763	de
	H3 = 100cm	1292	f	325	f	75.7	bc	9.40		2.99		1.6863	e	0.4237	f