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Effect of Water Supply on Vegetative Growth and Yield Characteristics in Onion (*Allium Cepa* L.)

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Abstract: The present experiment was conducted during 2004/2005 and 2005/2006 seasons to study the effect of irrigation regimes on vegetative growth of onion plants cv. Giza 6. Six water supplies were applied in the field. The water quantity ranged between 350 to 3750 m^3 /fed with 15 or 30 days irrigation interval. Results indicated that the higher water supply resulted in higher vegetative parameters: Plant height, number of leaves per plant, bulb and neck diameter. Bulbing ratio showed reverse as the lowest water supply resulted in higher bulbing ratio. Dry matter content showed high negative correlation with applied water quantity in both leaves and bulbs. Higher water supply increased double and bolter while decreased exportable bulbs. There were positive correlation between vegetative growth and total bulb yield.

Key words: Water supply - Onion growth -Vegetative parameters - Dry matter.

INTRODUCTION

Onion (*Allium cep*a L.) is an important vegetable crop in Egypt for exportation and local consummation. As a result of the changes in climatic conditions, irrigation systems, soil properties and new released varieties the water requirements of onion plant needs more studies. Onion is a shallow-rooted plant that requires frequent irrigation to achieve good yield. Accordingly excessive amount of water is generally applied to fields. On irrigated land the onion crop is regarded as a fairly large consumer of water. Onions under water deficiency decrease in its evapotranspiration and consequently yield (Sammis *et al.,* 2000).

Ells *et al*., (1993) reported that onion grown under furrow irrigation system requires 1040 mm of water to achieve a 59 t ha^{-1} yield in the Arkansas River Valley of Colorado. Al-Moshileh (2003) reported that soil water quantity improved plant growth parameters and total yield while marketable yield was reduced. Olalla *et al*., (2004) in drip irrigation experiment reported that the lower volume of water received, the higher the efficiency obtained. They reported that onion irrigation requirements being in the region of 6000 m^3/h^{-1}.in Spain.

Kadayifci *et al.,* (2005) reported that bulb and dry matter production were highly dependent on appropriate water supply. Mermoud *et al*., (2005) showed that irrigation frequency plays an important role on the development and yield of the onion crop. Irrigating twice a week instead of once a day (and thus increasing the irrigation depth) was found to cause an increase of the water storage through the whole root zone, a better crop water availability and higher yield. Bekele and Tilahun (2007) observed that water deficit at first and fourth growth stages had insignificantly effect on yield as compared to optimum application. If the water deficit is in the second and third growth stages, or during all stages as 25%ETc, 50%ETc, and 75%ETc water deficit, the yield were significantly different from optimal irrigation. All deficit levels increased the water use efficiency of onion from a minimum of 6% by stressing the crop.Sarkar*et.al*.(2008) reported that, at lower irrigation quantities the water use efficiency is higher. Relative to the yield obtained at 0.6 ETp, yield at1.0ETp increased by 23–25% while at 1.4ETp it was only 3–9% greater than that at 1.0ETp. In contrast, yield at 1.6ETp was 9–12% less than that at 1.4ETp (ET = crop evapotransiration of onion crop as estimated by the FAO Penman).

Water shortage is one of the impotent problems over the last few years. For this reason, all irrigation regimes for all produced crops in Egypt especially for the diverse soils of some vegetable crops need more investigations. The purpose of this work was to study the optimum water supply of onion (variety Giza 6) under heavy clay soil conditions and its relations to the optimum vegetative growth which will lead to the higher total bulb yield.

MATERIALS AND METHODS

This investigation was carried in a clay soil of experimental farm of Assiut University, Assiut,Egypt in 2004/2005 and 2005/2006 seasons. The aim of this study was to identify the relation between water supply applied in field and the vegetative growth through the growing season. Seeds of Giza 6 cv. were sown on 20^{th} September in a nursery. Transplanting take place at November 29^{th}. Seedling were spaced 5-7 cm apart in lines 15 cm in between. The plot size was 4 m^2 and consisted of 200 seedlings.

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Applied Water Supply:

Applied six water supplies in this study are shown in Table (1)

Table 1: Applied water supplies.

Water supply	Irrigation interval (Days)	Number of irrigations	Total water quantity m^3 /feddan	Remarks
1	----------------	1	350	At transplanting only
2	----------------	2	700	At transplanting and manuring
3	15	8	3850	
4	15	8	7350	
5	30	4	1850	
6	30	4	3350	

The amount of water was measured by a water meter. Irrigation was withholded two weeks before harvest.

The Recorded Data:

1- Plant height (cm). (length of the longest leaf).
2-Number of leaves / plant.
3-Neck diameter (cm).
4- Bulb diameter (cm).
5- Bulbing ratio
6-Percent dry matter of leaves.
7-Percent dry matter of bulb.

Measurements were taken at Jan. 8, Feb. 8, March 8 and Apr.8. in 2004/2005 and 2005/2006 seasons, using 5 plants from each plot. The mean for each character was calculated.

Experimental Design and Statistical Analyses:

The used design was complete randomize block with three replications. The main plot was water quantity while four samples were taken at four growth stages from each main plot. The data were subjected to statistical analysis using F test and means were compared using Duncan's multiple range test. Combine analysis over the two seasons was done. All possible correlations were calculated to estimate the R values between water supply and the other characters.

Results:

I- Main Effect of Irrigation on Vegetative Parameters:

Table 2 shows means of vegetative records under irrigation treatments regardless the sampling dates. It is clear that water supply had highly significant effect on all studded vegetative characters in the two seasons of the study. These results were demonstrated by many investigations.El-Oksh *et al.* (1993) reported that plant height, number of leaves, fresh and dry weight increased with increasing soil moisture level. Thabet *et al.* (1994) indicated that the number of leaves, leaf and bulb dry matter and bulbing ratio were increased by increasing irrigation.El-Haris and Adbel Razek (1997) revealed that growth characteristics, yield and yield components generally improved with the increased in total water applied during growing period. El-Mansi *et al.* (1999) found that in drip irrigation system with 2 days interval resulted in the highest dry weights. Water supply of 2600 m^3/fed. significantly resulted in the highest values of dry weight of different plant organs, as well as total dry weight per plant.

Table 2: Main effect of irrigation on vegetative parameters of onion cv.Giza 6 during 2004/2005 and 2005/2006 seasons.

Water supply	Plant height	No. leaves per plant	Neck diameter	Bulb diameter	Bulbing ratio	Dry matter in leaves	Dry matter in bulbs
1	40.1 D	5.33 C	1.04 E	3.03 D	3.16 B	11.4 B	14.9 A
2	40.9 D	6.00 B	1.14 D	3.30 C	3.20 A	12.4 A	14.4 B
3	53.4 A	6.77 A	1.56 A	3.75 A	2.33 E	10.7 C	13.5 C
4	52.6 A	6.00 B	1.58 A	3.54 B	2.21 F	9.4 E	11.2 E
5	45.0 C	5.83 B	1.26 C	3.53 B	3.00 C	10.9 C	14.3 B
6	49.0 B	5.94 B	1.43 B	3.60 B	2.84 D	9.7 D	12.4 D
L.S.D.05	**2.43	**0.35	**0.36	**0.11	**0.026	**0.30	**0.39

Kumar *et al.,* (2007a) compared different irrigation levels on onion with microsprinkler irrigation system. The used four treatments comprised different ratio of irrigation water (IW) to cumulative pan evaporation (CPE) 0.60, 0.80, 1.0 and 1.20. Irrigation had significant effect on growth parameters of onion and subsequently influenced the crop yield. Al-Moshileh (2007) reported that with increasing soil water supply recorded plant growth parameters; i.e. plant height, number of green leaves and bulb diameter were significantly increased in the tested growing seasons.

II- Effect of Irrigation X Growth Stage on Vegetative Parameters:

The interaction between irrigation and growth stage showed significant effect on all studded vegetative characters in both seasons of the study. The showed data is the mean of the two seasons.

Plant Height (cm):

Figure 1 show the plant height along the growth period from Jan. 8.to Apr.8 under each level of water supply. It is clear that there was an increase in plant height as growing season advanced from January to March when plants of the same plot arrived to the maximum value. Then decreased in April when the oldest leaves yellowed and started to down low.

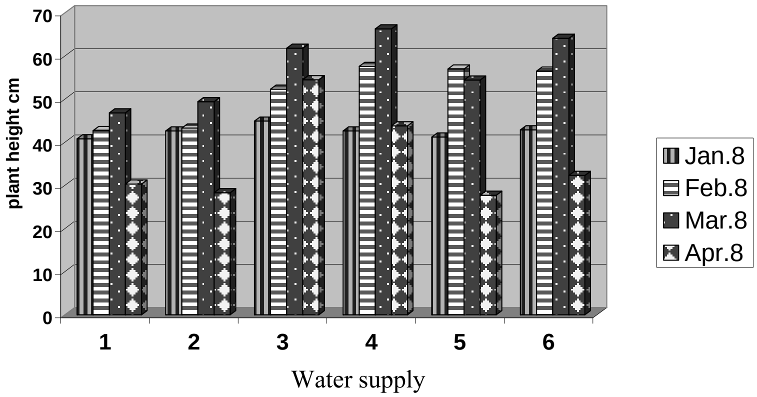

Fig. 1: Mean plant height over 2004/2005 and 2005/2006 seasons at 4 growth stages under each water supply in onion plants cv.Giza 6.

Plots which received larger amount of water showed significantly taller plants compared with plants which received lower amounts at the same date of sampling. The tallest plants were obtained by regime 4 which received 7350 m^3/fed.The shorter plants were obtained by regimes 1and 2which received 350 and 700 m^3 /fed. This interaction was high significant with L.S.D. value 4.85**. Aujla and Samadan (1992) reported that irrigation had significant effect on plant height.

Number of Leaves Per Plant:

Figure 2 show the effect of irrigation regime x growth stage on number of leaves per plant. Larger amount of water was associated with more leaves per plant. Under all irrigation regimes plants prolonged to form new leaves gradually to March end. In April the number of leaves decreased as a result of dried outer leaves when bulbs started maturity stage.Regime3 which received a 3850 m^3/fed. produced significantly the largest number of leaves (8.1leaves/plant at March 8).The same treatment saved the highest number in April month compared with the other treatments in which the number dropped in this time. The lowest number of leaves was obtained by regime 1 which received water one time only at transplanting date (6.7 leaves /plant at March 8) The interaction between irrigation and growth stage was high significant with L.S.D. value 0.71**.

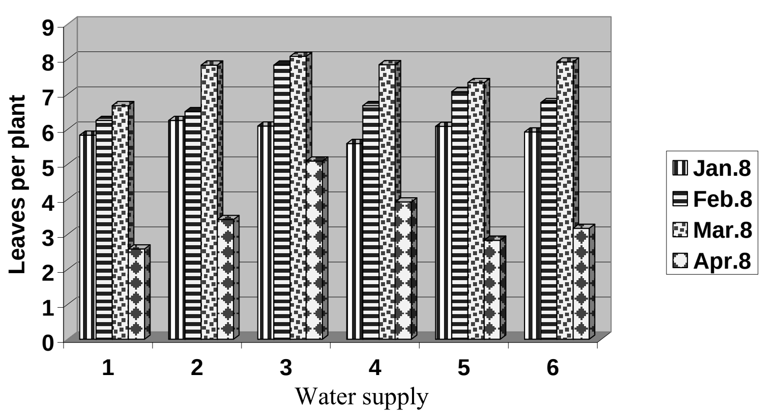

Fig. 2: Mean number of leaves per plant over 2004/2005 and 2005/2006 seasons at 4 growth stages under each water supply in onion plants cv.Giza 6.

3- Neck Diameter (cm):

The data of neck diameter are presented in fig. 3. The neck diameter increased gradually from January up to March and then decreased in April as a result softening during maturity stage. The highest value of neck diameter was obtained by plants which received 7350 m^3 /fed. (2.10 cm in March 8) while regime1 which received one irrigation only at transplanting recorded the lowest values (1.3cm.at the same date). Although the neck diameter decreased at maturity,regimes 3 and 4 received 3850 and 7350 M^3/fed. respectively saved stronger and wider necks to April compared with others. The highly significant response of this character was with L.S.D. 0.073**. Al-Moshileh 2007 showed that higher level of applied water resulted in a significantly thicker necks.

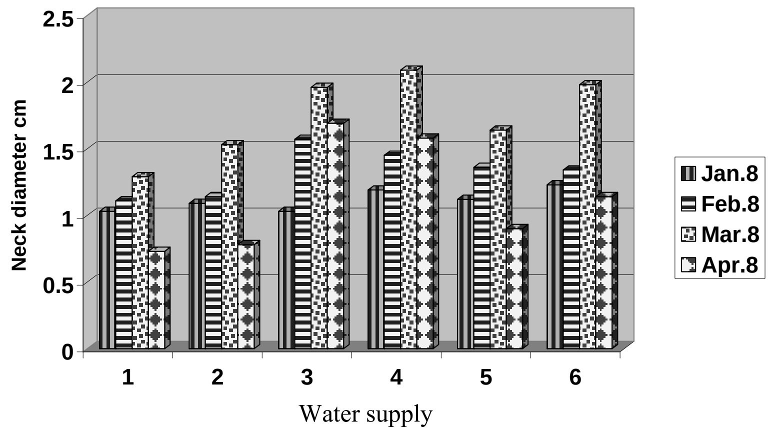

Fig. 3: Mean neck diameter in 2004/2005 and 2005/2006 seasons at 4 growth stages under each water supply in onion plants cv.Giza 6.

4-Bulb Diameter (cm):

Fig. 4 shows the data of bulb diameter. All irrigation regimes arrived to the maximum bulb diameter at April 8. The wider bulbs were obtained by plots which received 3350 m^3/fed. while the lowest value was recorded in regimes 1 and 2. There were significant differences between treatments with L.S.D. 0.21**. To save the water it is logic to produce wide bulbs with the possible lower water supply.

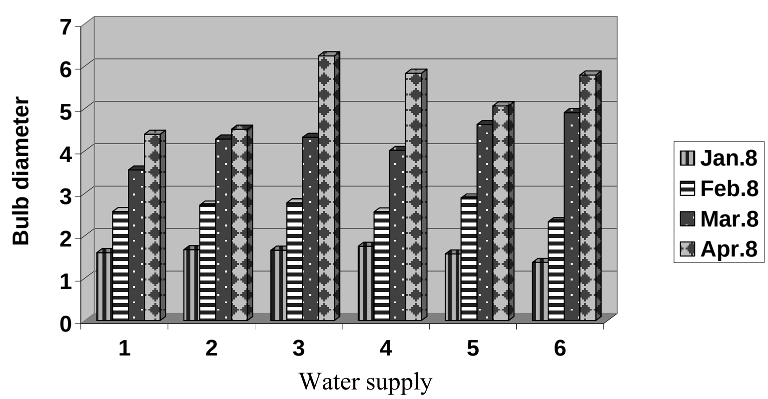

Fig. 4: Mean bulb diameter over 2004/2005 and 2005/2006 seasons at 4 growth stags under each water supply in onion plants cv.Giza 6.

Olalla *et al.*, (2004) reported that plots which received the greatest volumes of water during the development and ripening stages yielded harvests with higher percentages of large-size bulbs whereas the water shortages induced during the growth and bulbification stages led to higher percentages of small-size bulbs. Kumar *et al.*, (2007b) reported that Irrigation at 1.20 Ep and fertigation at 200 kg/ha resulted in the highest bulb size and weight.

5- Bulbing Ratio:

Figure 5 presents the values of bulbing ratio. Lower water supply higher bulbing ratio.

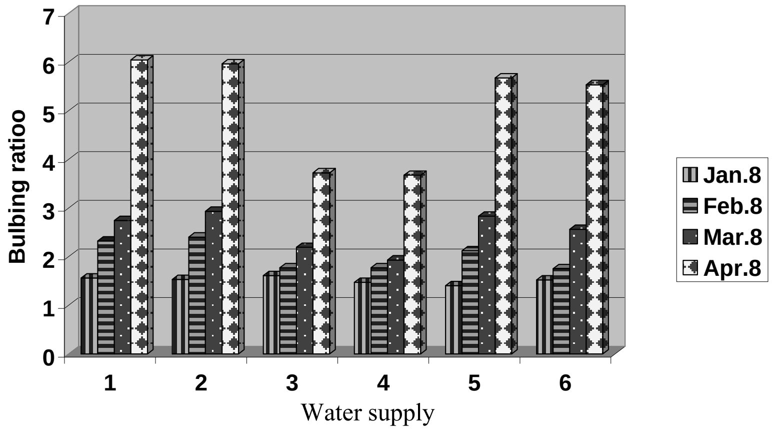

Fig. 5: Bulbing ratio over 2004/2005 and 2005/2006 seasons at 4 growth stages under each water supply in onion plants cv.Giza 6.

Regimes 1 and 2 had the highest ratio 5.7 and 5.5 at the end of the season. Bulb diameter was 5.7 and 5.5 times as the neck diameter. Higher water quantity resulted in lower values of bulbing ratio as the bulb diameter was 4.1 and 4.0 times as the neck diameter in regimes 3 and 4 respectively. Gamie *et al.* (2000) reported that different irrigation treatments had not significant effect on the bulbing ratio

6- Dry Matter in Leaves:

The data of leaves dry matter percentage is illustrated in figure 6.Growth stage had high significant effect on dry matter in leaves with L.S.D.0.60.The last growth stage showed the maximum dry matter Regime 5 recorded the highest value 13.81 %.The lowest value was in plots of regime 4 which received the highest water quantity. It is remarkable that water supply which received high water quantities showed unstable behavior as showed high value at one stage and then lower percent at the later stage.

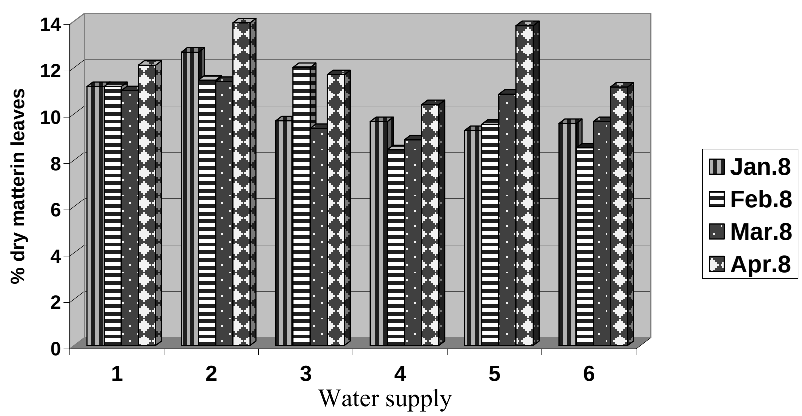

Fig. 6: Dry matter in leaves over2004/2005 and 2005/2006 seasons at 4 growth stages under each water supply in onion plants cv.Giza 6.

7-Dry Matter in Bulbs:

Fig 7 shows the mean dry matter percentage in the bulbs over the two seasons. The response was high significant with L.S.D. value 0.79. Regime 1 which received 350 m^3 showed 17.38 % and regime 5 which received 1850 m^3 water recorded 17.54 % dry matter in bulbs at the latest growth stage. All water supply showed gradually increase in dry matter from first stage to last stage but regime 4 which received 7350 m^3/fed.showed lower percent at the second stage compared with the first stage.

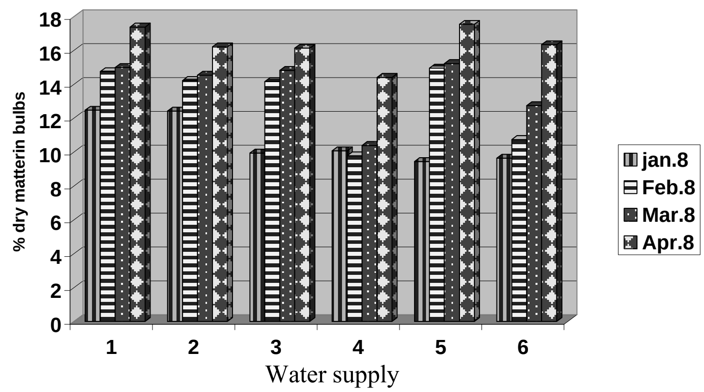

Fig. 7: Dry matter in bulbs over 2004/2005 and 2005/2006 seasons at 4 growth stages under each water supply in onion plants cv.Giza 6.

Olalla *et al.,* (2004) reported that the dry matter yield was not affected by the total volume of water intake (with volumes ranging from 603.1 to 772.0 mm) in drop irrigation system. Pfülb and Zengerle (1990) reported that the water quantity or bulb size not affect the dry matter in bulbs. Gamie *et al.,* (2000) Studded the effect of water supply on dry matter in bulbs and he found that it had not significant effect on dry matter after 90 days from transplanting in all studded varieties in both seasons of the study. Sorensen and Grevsen (2001) concluded that water deficit resulted in higher dry matter percentage in bulbs. Kumar *et al.,* (2007b) reported that irrigation at 1.20 Ep (highest water supply) and fertigation at 200 kg/ha produced higher dry matter yield.

7- The Significance and L.S.D. Values for the Factors and Their Interactions:

Table 2 show the values of L.S.D. at 0.05 of effect of the other studied factors and interactions on vegetative growth of onion plants cv.Giza 6. The season and growth stage significantly affected all studded vegetative characters.All interactions showed significant effect on all studded characters

Table 2: Significance and L.S.D.values at 0.05 for the effect of interactions on the vegetative growth of onion plants cv.Giza 6 over 2004/2005 and 2005/2006 seasons.

Characte/ Factor or interaction	Season	Season x Rep.	Season x irrigation	Sample	Season x sample	Irrigation x sample	Sea x irri.x sample
Plant height	**	n.s.	**3.44	**1.98	n.s.	**4.85	**6.88
No. leaves/plant	**	**0.35	**0.50	**0.29	**0.41	**0.71	**1.00
Bulb diameter	n.s.	n.s.	**0.15	**0.09	**0.12	**0.21	**0.30
Neck diameter	**	n.s.	**0.05	**0.03	**.04	**0.07	**0.11
Bulbing ratio	**	**0.03	**0.04	**0.02	**0.03	**0.05	**0.07
Dry matter in leaves	**	n.s.	** 0.42	**0.25	**0.35	**0.60	**0.85
Dry matter in bulbs	**	**0.39	**0.56	**0.32	**0.45	**0.79	**1.11

* Significant effect at 0.05 ** Significant effect at 0.01

III- Correlations Coefficient (R) :

1- Correlations Coefficient (R) Between Water Supply and Vegetative Parameters:

The calculated values of Correlations Coefficient (r) between water supply and vegetative parameters are presented in table 3.Water supply showed high significant correlation with plant height and neck diameter. Dry matter in both leaves and bulbs and bulbing ratio decreased with increasing the water quantity. Doorenbos and Kassam (1986) reported that during the vegetative and ripening periods, the crop appears to be less sensitive to water deficit. Excessive irrigation during the vegetative period can lead to a delayed and reduced bulb development. Abbey and Joyce (2004) reported that deficit irrigation especially on the sandy loam caused physiological stress that reduced spring onion growth and dry-matter yield compared to regular irrigation. Kumar *et al.,* (2007a) reported that bulbs having diameter greater than 45 mm. Protein content in bulbs was highest in plots which received 0.60 of cumulative pan evaporation (CPE) compared with 0.80,1.0, and 1.20.

2-Correlations Coefficient (R) Between Water Supply and Bulb Yield Grades:

Table 4 shows the calculated Correlations Coefficient (r) between water supply and yield grades of onion. Increasing water quantity decreased the exportable bulbs while increased double and bolters.

Table 3: Correlation Coefficient (*r*) between water supply and the vegetative parameters in onion plants cv.Giza 6 over 2004/2005 and 2005/2006 seasons.

	Plant height	No.leaves/p	Bulb diam.	Neck diam.	Bulb. ratio	Dry mat. L.	Dry mat.bu.
Water supply	0.39**	0.096	0.10	0.47**	-0.23**	-0.48**	-0.40**
Plant height	-----------	0.72**	0.02	0.79**	-0.58**	-0.55**	-0.29**
No. leaves/plant		-----------	-0.28**	0.65**	-0.71**	-0.48**	-0.36**
Bulb diameter			-----------	0.31**	0.69**	0.26**	0.60**
Neck diameter				-----------	-0.41**	-0.40**	-0.17*
Bulbing ratio					-----------	0.55**	0.66**
Dry matter in leaves						-----------	0.60**

R values are calculated from 144 means over two seasons

Table 4: Correlations Coefficient (*r*) between water supply and bulb yield grads over the two seasons 2004 and 2005 in onion cv. Giza.

	Exp. Bulbs	Sc.Bulbs	Double	Bolter	Mec. Inj.	Total yield
Water supply	-0.66*	0.38	0.60*	0.57*	0.16	0.50
Exp. Bulbs	-----------	-0.15	-0.72**	-0.76**	-0.60*	-0.50
Sc.Bulbs		----------	0.31	0.19	0.10	0.80**
Double			---------	0.92**	084**	0.80**
Bolter s				-----------	0.80**	0.69*
Mech. Injured					-----------	0.65*

R values are calculated from 12 means over two seasons

Pelter *et al.,* (2004) showed that total yield was reduced by soil-water stress imposed at any growth stage but the greatest effect was at the and 3- and 7-leaf stages. Soil-water stress caused by withholding irrigation at both the 3- and 7-leaf stages reduced yields by 26% compared with the control. The percentage of single-center onion bulbs was lower when the soil-water stress occurred earlier in the growing season than when the stress occurred later. Single-center bulbs was reduced by 40, 32, and 18% when soil-water stress was imposed at the 3- and 7-leaf, 3-leaf, and 5-leaf stages, respectively.

3- Correlations Coefficient (R) Between Vegetative Parameters and Bulb Yield:

Correlations Coefficient (*r*) shown in table 5 indicated that plant height,number of leaves per plant neck diameter and bulb diameter had positive significant correlation with total yield while the same parameters showed negative significant correlation with exportable bulbs. Dry matter percent in bulbs showed significant positive correlation with exportable bulbs while this relation was negative with scales, double and bolter bulbs and total yield.

Table 5: Correlations Coefficient (*r*) between vegetative parameters and bulb yield grads over the two seasons 2004/2005 and 2005/2006 in onion cv. Giza 6.

	Leave s /plant	Neck diam.	Bulb diam.	Dry mat.lea.	Dry mat. bulbs	Exp. Bulbs	Scalles .Bulbs	Double bulbs	Bolter s	Mech. Injured	Total yield
Plant height	0.64*	0.98**	0.74**	-0.72**	-0.79**	-0.76**	0.63*	0.85**	0.73**	0.59*	0.87**
leaves /plant	--------	0.62*	0.32	-0.26	-0.24	-0.68*	0.23	0.75**	0.70**	0.85**	0.64*
Neck diam.		---------	0.76**	-0.69*	-0.79**	-0.69*	0.59*	0.86**	0.71**	0.56*	0.84**
Bulb dima.			-------	-0.59*	-0.69*	-0.27	0.89**	0.43	0.23	0.16	0.77**
Dry mat.lea.				--------	0.83**	0.52	-0.46	-0.49	-0.46	-0.28	-0.55
Dry mat.bulb					------	0.61*	-0.44	-0.54	-0.41	-0.18	-0.51

R values are calculated from 12 means over two seasons.

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