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Effect of Irrigation Interval (Water Stress) on Vegetative Growth and Yield in Two Genotypes of Okra

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Abstract: This work was carried out at the Experimental Farm, Fac. Agric, Assiut University, Assuit. Tow genotypes of okra i.e., line 16 and the locally adapted type "Balady" were subjected to different irrigation interval i.e., 12, 18, 24 and 30 days receiving the recommended amount of irrigation water, (Central Institute of Agricultural Elinals). Results showed that plants of line 16 recorded higher values regarding plants height dry matter % in of each vegetative and root parts, fruit length and yield under all of the tasted irrigation intervals. However, the Balady genotype was superior to line 16 in respect of fruit weight and root length. Irrigation interval showed pronounced effect on most of the studied character. For example watering every 12 days gave the highest yield, greater number of roots, while prolonging irrigation up to 24 of the 30 days revealed the earliest flowering time (days) and it also led to closure of stomata in line 16. The most pronounced effect for the interaction was that fund between line16 when irrigated at 12 days intervals where the highest fruit yield and greatest number of roots were recorded in both seasons of study.

Key words: Production, drought, okra, efficiency, stomata.

INTRODUCTION

Drought is considered one of the most important factors that limiters plant production in arid and semi-arid zone (Ehdaie, 1995), where such areas are subjected to a wide range of climate variation as well as climate changes. Under such conditions lower yield and lower water use efficiency take place specialty under the instability of water amounts from year to year. (Owies *et al.* 2000). Moreover, the increase in area of arid and/or semi-arid lands along with the decrease in water resources attracted the attention for the improvement of better return of water unit of and land to gain higher yield while consuming minimal amount of water. Since traditional methods for irrigation are usually applied under the majority of farming system , this led to reduced efficiency of water unit as a results of more water loss in the form of evaporation, leaching as well as more water added as the crop requirement causing nutrient leaching or lodging for some plant crops. This makes it necessary to quantity water requirements to a crop and to minimize the loss in irrigation water. This could be achieved through applying the enough amount of water to witting the area in which the effective root system in spread (Owies *et al.,* 2000).

Okra is one of important vegetable crops belonging to Malvaceae. It is censured a fresh, carried, frozen or as pickles. Okra seeds are also used as protein source and can also dried and used as alternative for coffee in some Asian and African countries. Matlob *et al.,* (1989) indented the importance of time of irrigation and number of irrigations (irrigation interval) in increasing yield at better quality, whereas Fisher (1980) showed that water stress resulted in reduced yield and less quantity. However, khalil (2004) found significant differences among okra genotypes regarding number of days to flowering, plant height, number of branch /plant, early yield, total yield and fruit length and weight. Mbagwu and Adesipe (1987) found that the greatest percentage reduction in okra fresh fruit yield occurred when moisture stress was imposed at the flowering stage of Kano Dwarf and Awgu Early. In all cultivars, moisture stress at both in flowering and pod-filling stages resulted in a reduction of more than 70% in fruit yields, while the lowest reduction in fruit yield occurred with moisture stress during the vegetative stage. Onwugbuta-Enyi (1996) indicated that, okra plant height was significantly reduced by water stress. Generally, plants subjected to a low level of stress (watered once a week) performed better than those moderately stressed (watered once every 2 weeks). Saeed *et al.,* (2003) found that fresh fruit yield per okra plant; number of branches per plant; of Parbhani Karanti and DLPG cvs.were not drastically affected by drought. The maximum reduction in these parameters was observed when water stress (three consecutive irrigation withheld) was imposed at the flowering and pod formation stages, suggesting that these stages were the most sensitive to drought. Khalil (2004) found that all okra genotypes showed significant differences for most of traits under irrigation regimes (10, 30 and 45 days). Selected lines 2 and 3 are the most tolerant to drought, where their S (drought susceptibility index) and RD% (The relative percentage of decrease) have the lowest estimates concerning number of fruits/plant and total yield. Lawal and Rahman (2007) reported

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that intercrops of okra (*Abelmoschus esculentus*) and pepper (*Capsicum annuum*) gave better yields and economic returns with application of 400 kg ha-1 of inorganic fertilizer, 5 t ha-1 of manure and 10-day irrigation intervals. Abbas (2007) found that Irrigation every 8 days during growing season significantly increased okra plant height, number of main branches per plant, dry weight of leaves and stems, mean fruit weight and plant yield (61.22 t/h and 178.63 kg/plant).

The objective of the present investigation was to study the effect of interval of irrigation with the aim of minimizing water consumption on growth and yield and its compacts in two genotype of okra i, e, 'line 16' and locally adapted 'Balady'.

MATERALS AND METHODS

This study was carried out at the Experimental Farm of Faculty of Agriculture, Assiut University, Assiut, Egypt, during 2007 and 2008 summer seasons. The study aimed to find out the performance of growth and yield of tow genotypes of okra i.e., line 16' and the locally adapted type Balady. The line 16 is a breeding line prodded by Dr. Hassan A. Hussein, Dept, of Hort, Assiut Univ. and refers to Sudanese type bred for two cycle of mass selection and characterized by smooth long fruits and plants had long stems while Balady cv. is the locally adapted type and usually used by the famers and well adapt for cultivation and consumer preface ability . Plants of the two genotypes were subjected to different irrigation intervals 12, 18, 24 and 30 days. Okra seeds were sown on Apr., 1 and Apr., 9 in the 2007 and 2008 seasons, respectively. Planting was arranged on ridges 80 cm apart with 30 cm spacing between plants. The area of each plot was 9 m^2 (Experimental plot was three rows). After complete emergence seedling were thinned to two plants/hill. Land was prepared including plowing to a depth of 30 cm and rotovating to a fine tilth to break up clods and to smooth the soil and surface of the ridges. Before cultivation and during soil preparation one third of the recommended N, P and K fertilizers were added to the experimental plots at the rate of 45 kg. N (ammonium sulfate), 30 kg P_2O_5 (calcium super phosphate) and 40 kg K_2O (Potassium sulfate) per fed in each season. Water quantity was calculated based on water requirements for the okra crop (F.A.O. publications). It was 5050 m^3 /fed under furrow irrigation conditions. (According to Ministry of Agriculture, Central Laboratory for Agricultural Climate). Considering the growth season which is 145 days (from April to August) and the irrigation interval water was usually applied along the growing season every about 12 days .This means that the number of irrigations is 12 times during the season. Then to calculate the water quantity in each irrigation for each plot the following equations was applied:

Water quantity in each irrigation = 5050 m^3 /12 = 420.8 m^3 /fed. in each irrigation

Water quantity in each irrigation for one $meter^2$ = 420.8 /4000 = 0.105 m^3.

Water quantity in each irrigation for one plot = 0.105 x 9 m^2 (the plot area) = 0.946 m^3

The water quantity for each plot measured by water meter.Irrigation intervals, number of irrigations and water quantities added along the growing season are presented in Table 1.

The applied experimental design was Split plot with 3 replicate. The cultivars contributed as the main plot while irrigation intervals were randomly distributed to the sub-plots.

Table 1: Number of irrigations and total water quantity applied along the growing seasons in Balady and line 16 cvs of okra during 2007 and 2008 summer seasons.

Irrigation interval (days)	Number of irrigation	Water quantity per one irrigation	Water quantity per plot during season
12	12	0.95 m^3 /plot	11.4 m^3
18	8	0.95 m^3 /plot	7.6 m^3
24	5	0.95 m^3 /plot	4.75 m^3
30	4	0.95 m^3 /plot	3.8 m^3

Recorded Data:

Average Plant Height (Cm):

Measured from the cotyledonary node to the growing apex of the main stem.

Average Root Length (Cm):

After 145 days from sowing, three representative plants were taken from each plot by digging the soil and roots at the depth of 50 cm. Roots were gently recovered by agitating root systems in plastic containers filled with tap water (Farghali, 1994).The root length measured as the length of the main root that detected from the cotyledonary node to its tip.

Average Number of Branches / Root:

In the same time of measuring of root length , all branches that formed on the main root were counted. .

***Average Stem Dry Weight /Plant (Kg)*:**

The upper parts were cut off till the cotyledonary node, then both vegetative parts were freshly weighed individually and dried (in a fan electric oven at 70 ˚C for 48 h followed by 2 h at 105˚C) and then weighed until constant weight .

Average Root Dry Weight / Plant (Kg):

Measuring of root dry weight per plant with the same method of measuring average stem dry weight per plant.

Total Yield (Ton/Fed.):

On plot basis total yield as ton / fed was calculated.

Earliness of Flowering (Days):

The number of days from planting to the first flower in the plot**.**

Average Fruit Weight (G):

Edible fruits were picked 5-6 days after flower opening (Shalaby 1975 and Patel and Dalal 1992). Samples of 10 fruits each were randomly taken from the middle of harvesting period in each plot at each planting date were measured and the average weight was calculated.

Average Fruit Length (Cm):

The same samples which used to measure average fruit weight were used to Measure average fruit length from the basal cap to pod tip as described by (Sistrunk *et al.,* 1960).

Stomatal Behavior:

Electronic microscopy was used to studying of stomata opening and closer on each upper and lower leave surfaces.

Statistical Analysis:

The obtained data of both seasons were subjected to statistical analysis according to Snedecor and Cochran (1980) and means of treatments were compared using Least Significant Differences (L.S.D.) at 5 %

RESULTS AND DISCUSSION

Average Plant Height (Cm):

Data presented in Table (2) indicate that 'line16' significantly surpuesed the 'Balady' genotype regarding plant height. Applying irrigation every 12 days resulted in the tallest plant as compared to the other three intervals of irrigates (18, 24 and 30 days); recording an average of 159.11 and 162.58 cm for average plant height during 2007 and 2008 season respectively. However, irrigation every 30days resulted in the shortest plants as average of both tested genotypes The interaction between genotype and irrigation intervals was significantl. Plants of line 16 received irrigation every 12 days recorded 176.22 and 186.67 cm for average plant height during 2007 and 2008 season, respectively.

Table 2: Average plant stem length (cm) in two okra cultivars ('Balady' and 'Line 16') as affected by irrigation interval during 2007 and 2008 seasons under Assiut conditions.

Cv	2007			2008		
Irrig. Inter (days)	Balady	line16	Mean	Balady	Line 16	Mean
12	142.00	176.22	159.11	138.48	186.67	162.58
18	135.33	167.22	151.28	135.05	177.22	156.14
24	116.00	140.22	128.11	125.33	138.89	132.11
30	103.89	112.33	108.11	112.83	115.44	109.14
Mean	124.31	149.00		127.93	154.56	
L.S.D 0.05	Cv= 2.55 Irri.= 3.61 Cvx Irri= 5.11			Cv=2.88. Irri.= 4.08 Cvx Irri = 5.76		

***Average Root Length (Cm)*:**

The data in Table (3) showed that, the average root length significantly affected by the irrigation interval in the two tested genotypes in both seasons of the study. Balady cv showed significantly higher values of length of root (38.17 and 32.19 cm.) than Line 16 which showed 34.8 and 29.2 cm. in 2007 and 2008 seasons. Irrigation interval had significant influence on length of root in both seasons, where the highest values of root length (44.61 and 40.28 cm in 2007 and 2008 seasons, respectively) were obtained with 12 days irrigation interval. The interaction between cvs and irrigation interval treatments was significant in 2007 and 2008 seasons, where the

highest value (45.22 and 43.22 cm in 2007 and 2008 seasons, respectively) was obtained from plants of Balady cv which irrigated with every 12 days.

Average Number of Branches / Root:

The data in Table (3) revealed that, Balady cv. recorded higher number of branches/ root (12.5 and 15.42 in 2007 and 2008 seasons, respectively), however the response was not significant in the second season 2008. The number of root branches per root decreased significantly as irrigation interval increased, this was true in both seasons of study. Where, the highest value of number of root branches per plant (18.34 and 24.5 in 2007 and 2008 seasons, respectively) was obtained with the application of 12 days irrigation interval, while, the lowest one (6.95 and 8.45 in 2007 and 2008 seasons, respectively) was obtained with the application of 30 days. The interaction between cvs and irrigation interval treatments was not significant in both seasons of the study.

Table 3: Average root length (cm) and number of branches/root in two okra cultivars as affected by irrigation interval during 2007 and 2008 seasons under Assiut conditions.

Number of branches /root			Root length (cm)			Cv. Irrig. Inter(days)
Mean	Line 16	Balady	Mean	Line 16	Balady	
2007 season			2007 season			
18.34	17.67	19	44.61	44.00	45.22	12
13.00	12.22	13.78	39.22	37.00	41.44	18
9.89	9.56	10.22	34.95	32.22	37.67	24
6.95	6.89	7	27.28	26.22	28.33	30
	11.59	12.5		34.86	38.17	Mean
Cv = 0.53 Irri.= 0.75 CvxIrri = ns			Cv = 0.89 Irri = 1.25 CvxIrri =1.77			L.S.D 0.05
2008 season				2008 season		
24.50	24.56	24.44	40.28	37.33	43.22	12
16.67	16.00	17.33	32.17	30.22	34.11	18
11.73	11.78	11.67	28.11	26.78	29.44	24
8.45	8.67	8.22	22.11	22.22	22.00	30
	15.25	15.42		29.14	32.19	Mean
Cv = ns Irri =1.77 CvxIrri = ns			Cv = 0.63 Irri.= 0.89 CvxIrri = 1.26			L.S.D 0.05

Average Stem Dry Weight /Plant (Kg):

Data in Table (4) showed that stem dry weight/plant was significantly affected by cultivar, irrigation interval treatments and their interaction in both seasons of study. Line 16 recorded higher values of stem dry weight 1.46 and 1.20 kg than the Balady cv. which recorded 1.38 and 1.06 kg in 2007 and 2008 seasons, respectively. Irrigation interval showed significant influence on stem dry weight/ plant in both seasons of the study. In the first season the highest value of stem dry weight was obtained by 18 irrigation interval (1.70 kg) while 12 days irrigation interval showed the highest value in the second season (1.47 kg).Irrigation every 30 days resulted in the lowest values of stem dry weight /plant (1.08 and 0.69 kg stem dry weight /plant in 2007 and 2008 seasons, respectively). Plants of Balady cv. which irrigated every 18 days showed significantly the highest value of stem dry weight per plant.

Table 4: Stem and root dry weights (kg) per plant in Balady and line 16 of okra as affected by irrigation interval in 2007 and 2008 seasons.

Root			Stem			Cv Irrig. Inter (days)
Mean	Line 16	Balady	Mean	Line 16	Balady	
2007						
0.33	0.33	0.33	1.54	1.81	1.26	12
0.30	0.34	0.26	1.70	1.49	1.90	18
0.28	0.33	0.22	1.37	1.36	1.37	24
0.25	0.32	0.17	1.08	1.18	0.98	30
	0.33	0.24		1.46	1.38	Mean
Cv = 0.01 Irri = 0.02 Cvx Irri = 0.02			Cv = 0.09 Irri.= 0.13 Cvx Irri = 0.18			L.S.D 0.05
2008						
0.32	0.32	0.32	1.47	1.49	1.44	12
0.27	0.30	0.24	1.40	1.38	1.42	18
0.27	0.32	0.21	0.97	1.15	0.79	24
0.22	0.28	0.16	0.69	0.79	0.58	30
	0.30	0.23		1.20	1.06	Mean
Cv = 0.02 Irri.= 0.03 Cvx Irri = 0.04			Cv =.0.20 Irri.= 0.28 Cvx Irri = 0.39			L.S.D 0.05

Average Root Dry Weight / Plant (Kg):

Data in Table (4) showed that root dry weight/plant was significantly affected by cultivars, irrigation interval treatments as well as their interaction in both seasons of study. Plants of Line 16 showed higher root dry weight /plant (0.33 and 0.30 kg root dry weight) than Balady plants which showed 0.24 and 0.23 kg root dry weight / plant in 2007 and 2008 seasons, respectively. The shortest irrigation interval (12 days) gave the highest

values (0.33 and 0.32 kg root dry weight /plant in 2007 and 2008 seasons, respectively). However, the lowest values of root dry weight / plant (0.25 and 0.22 kg dry weight of root in 2007 and 2008 seasons, respectively) were obtained with the longest irrigation intervals (30 days).

Total Yield (Ton//Fed):

Data presented in Table (5) show that the total fruit yield in the two tested okra genotype was affected by irrigation interval during both seasons of study however the the differences were not significant under all tested treatments. Line 16. gave non significant higher fruit total yield (2 ton/fed. and 1.4 ton./fed) than Balady cv. which gave 1.76 ton/fed. and 1.23 ton/fed. in 2007 and 2008 seasons respectively . The wider irrigation interval the lower was the total fruit yield. For each of the tested cultivars, the highest total fruit yield was obtained when irrigation was applied at 12 days intervals.

Earliness of Flowering (Days):

As shown in Table (5) the two tested genotype of okra responded differently to the different irrigation intervals regarding number of days to flowering. Plants of line 16 flowered earlier in both seasons of study. The longer irrigation interval enhanced earlier flowering. The latest to flower was plants irrigated every 12 and 18 day in both cultivars in both seasons of the study. No significant effect was detected for the cultivar x irrigation interaction on the earliness of flowering. However, for each of the tested cultivars, there was a decrease in number of days to flowering as irrigation interval prolonged. The earliest to flower was line 16 (48.67 days) when irrigated every 30 days in 2007 seasons, however no significant differences were found in the 2008 season.

Table 5: Total yield (ton/fed) and earliness of flowering (day)in okra cvs. Balady and 16 as affected by irrigathon interval in 2007 &2008 seasons.

Earliness of flowering (day)			Total yield (tan/fed)			Cv. Irrig. Inter(days)
Mean	line 16	Balady	Mean	line 16	Balady	
2007 season			2007 season			
65	66.33	63.67	2.46	2.61	2.30	12
60.33	60.00	60.67	1.92	2.04	1.79	18
55.83	53.00	58.67	1.78	1.89	1.66	24
53.17	48.67	57.67	1.38	1.47	1.29	30
	57.00	60.17		2.00	1.76	Mean
Cv = 1.86 Irri.= 2.64 CvxIrri = 3.73			Cv =. ns Irri = ns CvxIrri = ns			L.S.D 0.05
2008 season				2008 season		
58.36	56.93	59.78	1.87	1.99	1.75	12
58.39	56.22	60.55	1.61	1.71	1.50	18
51.64	51.50	51.78	1.05	1.11	0.98	24
50.05	50.65	49.45	0.74	0.79	0.69	30
	53.83	55.39		1.4	1.23	Mean
Cv = ns Irri = 3.46 CvxIrri = ns			Cv = ns Irri.= ns CvxIrri = ns			L.S.D 0.05

Average Fruit Weight (G):

Data in Table (6) showed that the two tested genotypes significantly differed inaverage fruit weight according irrigation. Interval .The Balady cv. recorded the heaviest fruit, (4.99 and 4.25 g in 2007 and 2008 seasons, respectively). Irrigation interval had significant effect on the fruit weight in both seasons of study. The heaviest fruit (5.79 g and 4.66 g in 2007 and 2008 seasons, respectively) was obtained plants witch receved irrigation every 12 days. However, the smallest fruit weights (3.32 and 3.05 g in 2007 and 2008 seasons, respectively) were obtained with the longest irrigation interval (30 days). Fruit weight was insignificantly affected by the interaction between cultivars and irrigation interval treatments in both seasons of study. The highest values of weight of fruit were obtained from plants of Balady cv when grown under the shortest irrigation interval (12 days) recording 6.22 and 4.78 g. average of all tested genotype during 2007 and 2008 season, respectively.

Average Fruit Length (Cm):

Data in Table (6) concluded that, cvs exerted a significant influence on length of fruit in both seasons of study. Plant of line 16 cv gave the highest values (4.47 and 4.46 cm) of length of fruit in 2007 and 2008 seasons, respectively. The application of irrigation interval treatments had significant influence on length of fruit in 2007 season only, where the highest values of length of fruit (5.45 and 4.30 cm in 2007 and 2008 seasons, respectively) were obtained with 12 days irrigation interval treatment. The interaction between cvs and irrigation interval treatments was insignificant in both seasons of study, althou4gh the highest value (6.03 and 4.83 cm in 2007 and 2008 seasons, respectively) was obtained from plants of Line 16 cv when irrigated every 12 days.

Table 6: Fruit weight (g) and fruit length (cm) in two okra cultivars as affected by irrigation interval during 2007 and 2008 seasons under Assiut conditions.

Length (cm)			Weight (g)			Cv. Irrig. Inter(days)
Mean	Line 16	Balady	Mean	Line 16	Balady	
2007 season						
5.45	6.03	4.87	5.79	5.36	6.22	12
4.27	4.97	3.57	5.03	4.27	5.79	18
3.62	4.13	3.10	3.64	3.10	4.18	24
2.67	2.73	2.60	3.32	2.87	3.76	30
	4.47	3.53		3.90	4.99	Mean
Cv.= 0.27 Irri.= 0.38 CvxIrri = 0.54			Cv = 0.47 Irri = 0.67 CvxIrri = ns			L.S.D 0.05
2008 season						
4.30	4.83	3.77	4.66	4.54	4.78	12
4.10	4.57	3.63	4.11	3.54	4.68	18
3.97	4.37	3.57	4.02	3.81	4.23	24
3.78	4.07	3.50	3.05	2.81	3.29	30
	4.46	3.62		3.68	4.25	Mean
Cv = 6.23 Irri = ns CvxIrri = ns			Cv = 0.38 Irri.= 0.54 CvxIrri = ns			L.S.D.0.05

Stomatal Behavior:

The fluctuations of stomatal behavior (opening and closing of stomata) in the experimented plants under different irrigation regimes were shown in figure (1 and 2) and in photo plates (I & II). The stomatal type in okra plants is anisocylic or unequal celled type in case of okra a robiacious type of stomata is detected (subsidiary, cells are paracytic or parallel celled type). Mechanical movement of stomata in okra plants under changes in climatic factors and soil water stress indicating that the % of opened stomata in both leaf sides was lower then the closed stomata, particularly with shortage of soil water supply (24 days irrigation interval). The % of closing stomata in the upper, surface tended to a maximum (100%) under water stress in okra line 16 plants. In contrast, the stomata in the lower leaf surface of of Cv Balady are completely opened (100%) in the plants exposed to relatively high water stress (30 days irrigation interval). This may be due to lost of controlling on stomata aperture under soil water stress. This means that the stomata in the upper leaf surface are more resistant to water shortage which improve the water use efficiency in okra plants particularly okra line 16.

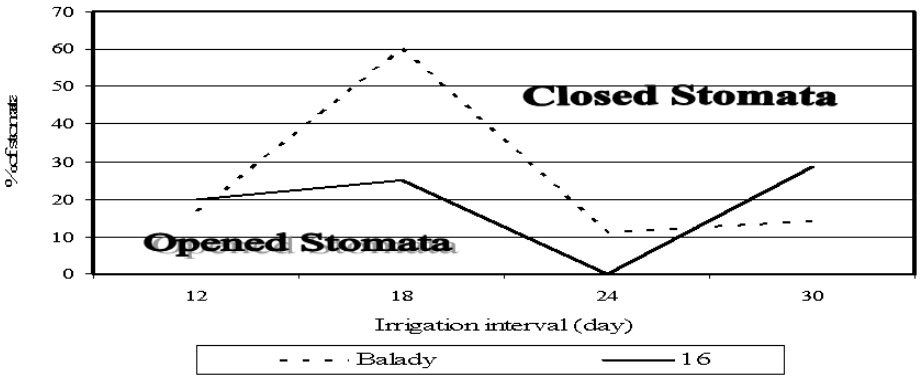


Fig. 1: % Opening and closing stomata in upper surface in okra under water stress.

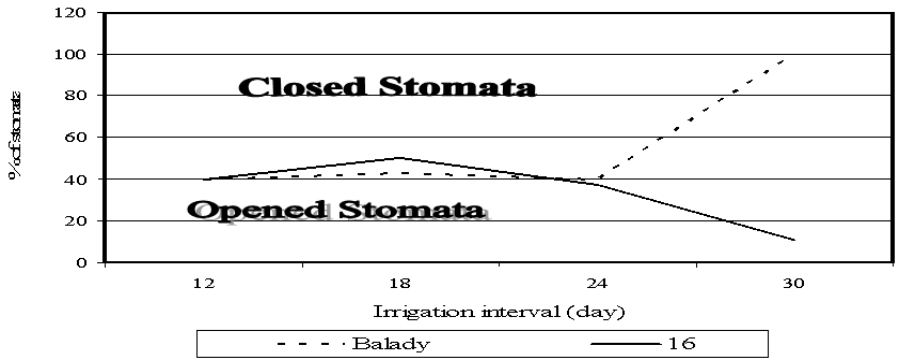
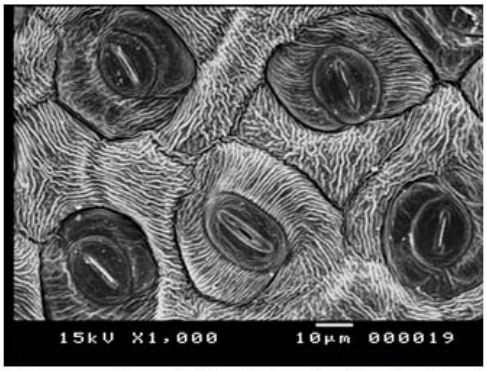
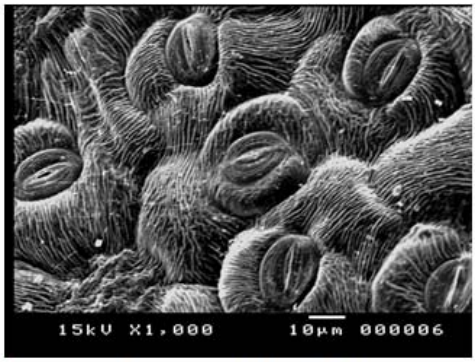


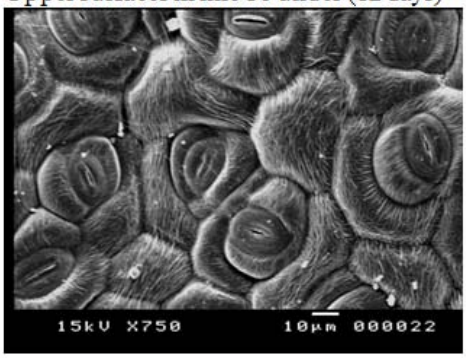
Fig. 2: % Opening and closing stomata in lower surface in okra under water stress.



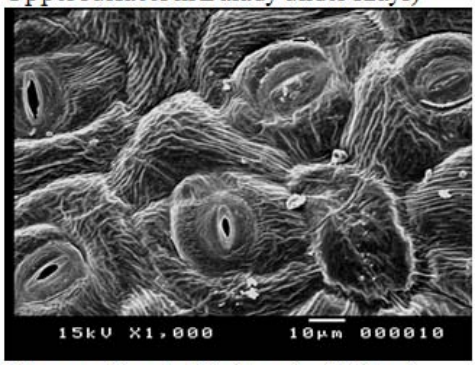
Upper surfaces in line 16 under (12 days)



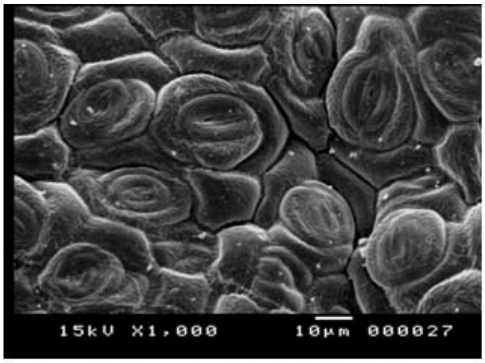
Upper surfaces in Balady under 12ays)



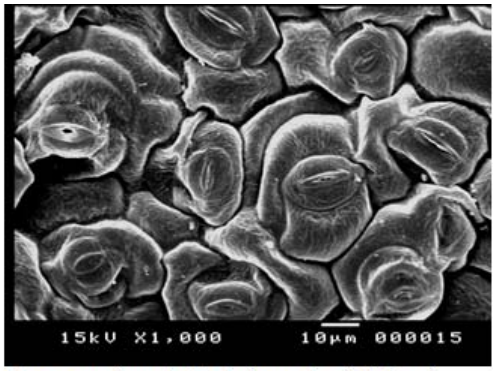
Upper surfaces in line 16 under (18 days)



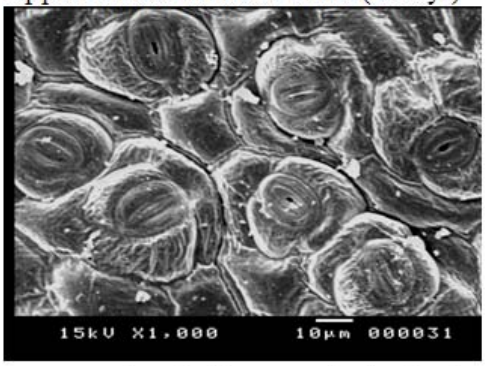
Upper surfaces in Balady under (18days)



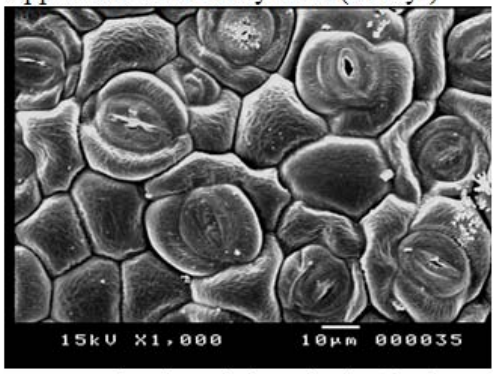
Upper surfaces in line 16 under (24 days)



Upper surfaces in Balady under (24 days)

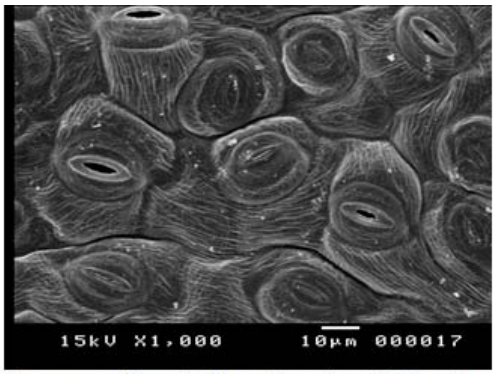


Upper surfaces in line 16 under (30 days)

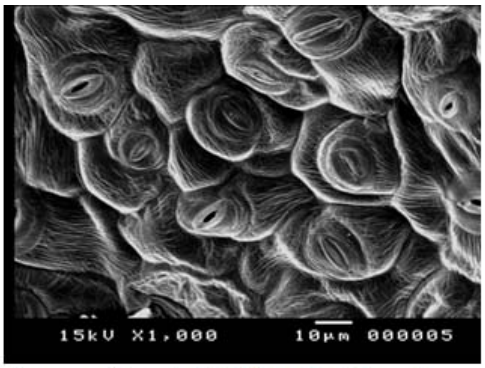


Upper surfaces in Balady under (30 days)

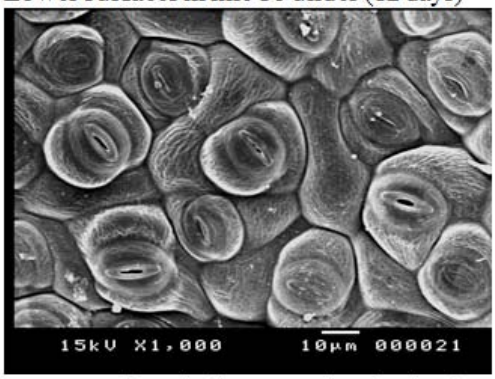
Plates I: Stomata in upper surface in okra leaf under water stress (12, 18, 24 & 30 days) (in 40 µm of leaf area).



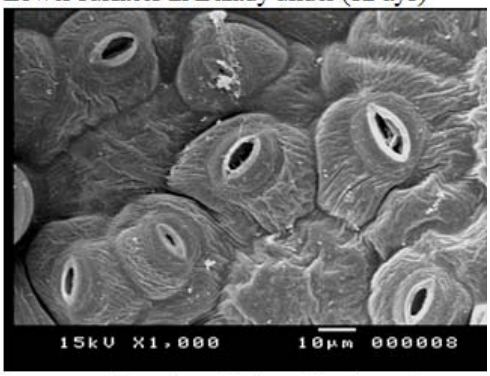
Lower surfaces in line 16 under (12 days)



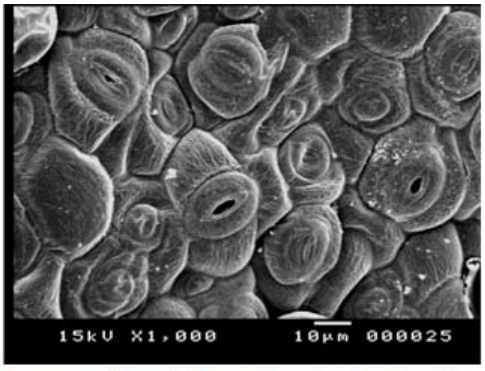
Lower surfaces in Balady under (12 ays)



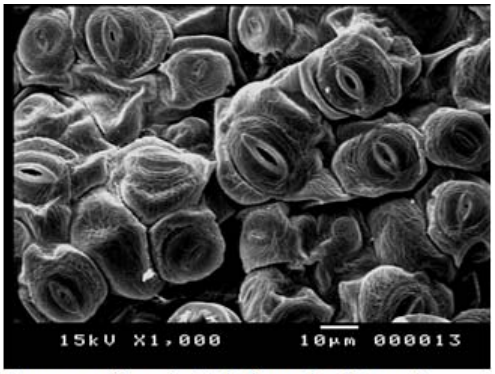
Lower surfaces in line 16 under (18 days)



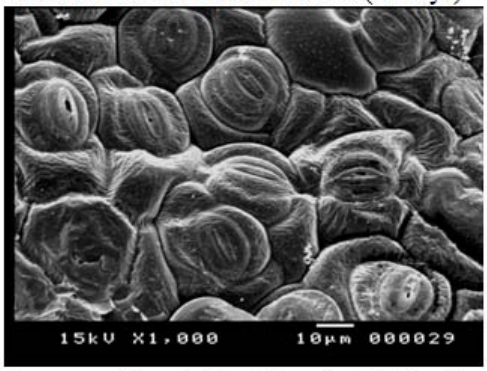
Lower surfaces in Balady under (18 ays)



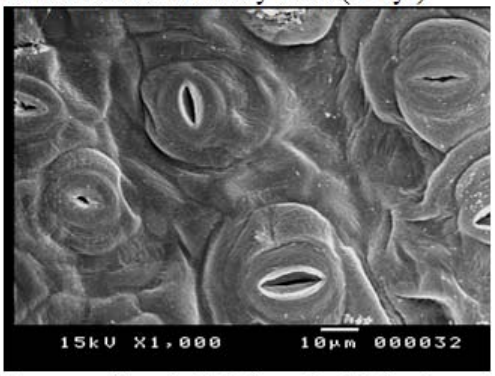
Lower surfaces in line 16 under (24 days)



Lower surfaces in Balady under (24 ays)



Lower surfaces in line 16 under (30 days)



Lower surfaces in Balady under (30days)

Plates II: Stomata in lower surfaces in okra under water stress (12, 18, 24 & 30 days) (in 40 µm of leaf area).

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