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EFFECT OF WATER STRESS ON STOMATAL CHARACTERS OF TWENTY ONE NEAR ISOGENIC LINES OF WHEAT *(Triticum aestivum* L.)

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Abstract

The present study was carried out to determine the effect of water stress on stomatal characters of flag leaf of wheat *(Triticum aestivum* L.) where five different irrigation regimes were considered as environments. Stomatal opening frequencies were significantly decreased by water stress in both the surfaces of the flag leaf in both irrigated and rainfed conditions in all the near isogenic lines of wheat. In rainfed condition, it was lower than irrigated condition. Similarly stomatal index also significantly differed in different irrigation treatments at three different positions in both adaxial and abaxial surface but under rainfed condition, it was lower than the irrigated condition in all the genotypes. The pore lengths of flag leaf in both adaxial and abaxial surfaces were found similar in size. It also varied among the different irrigations, but the variations were not remarkable. In rainfed condition, the pore lengths of different genotypes showed lower values than irrigated condition. Effects of water stress on stomatal pore breadths in both the surfaces were significantly decreased in rainfed condition. But in different irrigation conditions, stomatal pore breadth were non-significant among the genotypes. The effect of water stress on different stomatal characters in both surface of leaf in different lines of wheat were decreased.

Keywords: Water stress, stomatal characters, wheat .

Introduction

Rapid stomatal closure during the development of drought stress may account for the maintenance of higher water potentials in some cultivars. Stomatal aperture is an important index of drought tolerance since most transpirational water loss occurs through open stomata. Glover (1959) reported changes in stomatal response after repeated stress periods. Sullivan and Eastin (1975) pointed out the necessity of considering previous growth conditions when evaluating stomatal response to water stress. Several workers reported the importance of the structures above the flag-leaf node in contributing photosynthate to the developing grains of wheat (Carr and Wardlaw, 1965*;* Kriedemann, 1966; Quinlan and Sagar, 1965 and Voldeng and Simpson, 1967). Higher residual transpiration rates have been reported in leaves from irrigated than from rainfed field grown plants of wheat (Clark and McCaig, 1982). Senescence from the

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lower to the upper leaves is accelerated (Asana *et al., 1958)* with the result that the total supply of photosynthate to the plant is reduced. Considering the above view points in minds, the present investigation was undertaken to determine the water stress sensivity for area and stomatal behaviour of flag leaves of twenty one Near Isogenic Lines (NILs) of wheat *(Triticum aestivum* L.) at various growth stages under different schedule of irrigations and rainfed condition.

Materials and Method

Twenty one Near Isogenic Lines (NILs) of wheat *(Triticum aestivum* L.) obtained from different crosses between four Bangladeshi varieties (Aghrani, Akbar. Ananda, and Kanchan) and two dwarf selected lines (FM-132 and FM-139) of wheat were used as plant materials. The seeds of these lines were procured from the Cytogenetics Laboratory, Department of Botany, University of Rajshahi, Bangladesh. The present investigations were conducted in the experimentation field of Rajshahi University. The experimentation fields were prepared after repeated ploughings. The soil was measured properly. Uniform and saturated intercultural operations were done as and when necessary for all traits to raise the better crop. The Near Isogenic Lines of wheat were raised in split plot with three replications and evaluated at five irrigation (I) conditions: I_3 (irrigation was given at the root crowning stage, I_2 (I_2, + at the tillering stage), I_3 (I_3 + at the booting stage), I_3 *(*I_3 + at the heading stage), and I_0 (rainfed condition) treated as control. Transparent quick fix adhesives were spread on both the adaxial and abaxial surfaces of flag leaf. Allowed to dry for 30 minutes and then thin film of quick fix were taken out with the help of a fine forceps. The numbers of stomata from 30 random focuses from each surface of leaves were counted under a compound microscope and subsequently, the values were converted *and* expressed as number per mm^2 of leaf area.

The pore length and pore breadth of stomata of leaves were measured with the help of occulometer in a compound microscope using the values were converted into micron (μm) and the stomatal index of both ahaxial and adaxial surfaces of flag leaf of different genotypes were calculated and the data were analyzed statistically using conventional method.

Results and Discussion

Stomata are apparatus in the epidermis each bounded by two guard cells. In green leaves of monocotyledons, these stomata are arranged in parallel rows. In the present study, significant effect of soil moisture on stomatal number or density of stomata per mm^2 on both the adaxial and abaxial surfaces was found (Table 1). The stomatal number on the adaxial surface was found to be more than on the abaxial surface. Similar results were reported by Kazemi *et al.*, (1978) and Volkenbirrgh and Davies (1977). Number of stomata in both in adaxial and

Table 1. Mean values of stomata number per mm^2 of both adaxial and abaxial surface of leaf in twentyone near isogenic lines along with a check variety kanchan of wheat (*Triticum aestivum* L.) in different irrigation (I) condition.

Genotypes (G)	Adaxial surface					Abaxial surface				
	Irrigation (I)					Irrigation (I)				
	Control	I_1	I_2	I_3	I_4	Control	I_1	I_2	I_3	I_4
G1	40.33abc	44.33b-f	43.67de	43.67bcd	42.00efg	33.33bcd	38.00cd	39.67abc	39.33bc	38.67b
G2	40.67ab	45.00b-e	43.33def	44.67b	44.33bcd	34.67b	39.00bc	37.33def	37.33de	37.67bc
G3	39.33a-d	43.33d-g	44.67cde	43.67bcd	45.00b	37.33a	41.67a	40.33ab	41.67a	42.00a
G4	38.67b-e	42.33fgh	41.00g-j	43,67bcd	41.33fg	34.67b	40.67ab	36.67efg	36.67def	38.33bc
G5	38.33c-f	43.00efg	44.33de	43.67bcd	43.67b-e	31.33efg	35.67efg	35.00ghi	36.33efg	34.33efg
G6	41.00a	47.33a	45.67bcd	44.00bc	44.00b-e	30.67fg	34.67fgh	35.00ghi	34.33h-k	34.67ef
G7	38.33c-f	40.67hi	43.00efg	41.67d-g	42.67c-f	28.33i	32.00j	33.00jk	32.67k1	32.33h
G8	37.33d-f	41.67gh	42.67e-h	40.67fgh	41.00fgh	30.33gh	34.00f-i	33.67ijk	34.33h-k	33.67fgh
G9	36,33f	39.33ij	4067hij	39.00h	41.33fg	32.33def	36.00ef	34.67hij	36.00e-h	35.00def
G10	40.00abc	44.33b-f	46.67abc	42.33c-f	45.00b	30.33gh	34.67fgh	34.33h-k	41.00ab	36.67cd
G11	36.67ef	37.33j	41.33f-i	39.00h	40.00gh	32.67cde	36.67de	34.33h-k	35.00f-j	35.67de
G12	37.67def	41.33ghi	39.00j	41.33efg	39.00h	30.00ghi	34.00f-i	35.00ghi	34.33h-k	35.00def
G13	40.00abc	44.00c-f	48.33a	47.33a	48.00a	30.67fg	34.67fgh	35.67fgh	39.67bc	38.67b
G14	37.33def	43.00efg	43.67de	42.00c-f	44.67bc	33.33bcd	38.33cd	38.67bcd	38.33cd	38.33bc
G15	37.33def	42.67fgh	39.33ij	39.67gh	40.00gh	34.33bc	38.33cd	38.00cde	38.33cd	38.33bc
G16	38.67b-e	44.00c-f	42.67e-h	44.67b	44.00b-e	28.67hi	32.33ij	33.67ijk	34.67g-j	34.67ef
G17	40.67ab	46.00abc	47.00ab	44.00bc	46.00ab	30.67fg	34.33fgh	34.33h-k	36.00e-h	34 33efg
G18	38.33c-f	45.33a-d	44.00de	44.67b	45.67b	30.33gh	33.67g-j	32.67k	32.331	32.67gh
G19	41.00a	46.33ab	46.67abc	45.33ab	44.67bc	31.33efg	35.33efg	34.67fgh	35.67e-i	35.00def
G20	37.33def	44.33b-f	44.00de	44.67b	42.33dcfr	30.67fg	35.00efg	34.67hij	33.67jk1	36.67cd
G21	37.33dcf	40.67hi	40.00ij	43.33b-e	42.67c-f	28.67hi	33.00hij	32.67k	34.00i-l	34.67ef
Kanchan	39.33a-d	45.33a-d	45.00b-e	43.67bcd	44.00b-e	33.33bcd	39.33bc	41.33a	42.00a	41.33a
CV(%)			3.0					3.1		

In a column, means followed by a common letter are not significantly different at the 5% 1ee1 by DMRT.

Table 2. Mean values of stomatal index (%) of both adaxial and abaxial surface *of leaf in twenty one near isogenic lines along with a check variety* kanchan of wheat *(Triticum aestivum* L.) in different irrigations (I).

Genotypes (G)	Adaxial surface					Abaxial surface				
	Irrigation (I)					Irrigation (I)				
	Control	I_1	I_2	I_3	I_4	Control	I_1	I_2	I_3	I_4
G1	67.02cde	67.35fg	68.57c-f	68.40e-h	66.32g	63.74c	66.06c	66.06c	66.65b	66.8lab
G2	69.02a	70.41a	70.03a	70.06	70.14a	64.37b	67.67a	67.67a	66.73ab	66.79ab
G3	66.28d-h	66.08hi	66.42g	66.66jk	68.00def	64.98a	66.91b	66.91b	66.25bc	67.22a
G4	63.30k	68.17c-f	67.72f	69.33b-e	67.84def	64.70ab	67.42ab	67.42ab	65.llef	66.68ab
G5	66.22d-i	68.7lbcd	68.93bcd	69.42bcd	69.l2bc	62.39d	64.85de	64.85de	65.84cd	65.25ef
G6	65.80f-i	67.84def	67.30g	65.751	66.02g	60.43f	61.94hi	61.94hi	62.80i	62.70k
G7	68.00b	69.24b	68.87bcd	69.04c-f	69.llbc	58.58h	60.79j	60.79j	61.88j	61.711
G8	67.llcd	68.50b-e	68.74b-e	70.35a	67.65ef	60.95ef	63.61g	63.61g	63.62h	63.76ij
G9	66.23d-i	64.86j	68.94bcd	68.0lgh	69.05c	62.84d	64.55ef	64.55ef	65.44de	64.27ghi
G10	65.62f-i	67.32fg	67.80efg	65.83k1	66.18g	59.52g	62.04hi	62.04hi	65.54de	64.57gh
G11	62.77k	65.34ij	67.67fg	67.09ij	67.57ef	52.19i	66.21c	66.21c	65.45de	65.37de
G12	65.33hi	66.45gh	65.59h	67.63hi	65.88gh	62.46d	64.65ef	64.65ef	64.78fg	64.78fg
G13	66.57c-f	68.21c-f	70.03a	69.l0c-f	70.04ab	62.63d	64.69e	64.69e	66.76ab	66.39bc
G14	64.36j	67.24fg	67.89efg	67.0lij	68.49cde	62.54d	65.36d	65.36d	64.43g	65.40ge
G15	66.82cde	66.l3hi	64.58i	64.89m	65.12h	64.2lbc	65.95c	65.95c	66.40bc	65.89cd
G16	66.41dg	69.26b	68.40def	69.85abc	69.0lc	61.55e	63.72g	63.72g	64.49g	65.84cde
G17	67.39bc	69.29b	70.16a	68.22fgh	69.28abc	61.14e	64.05fg	64.05fg	64.59fg	63.31j
G18	65.50ghi	68.64b-c	69.50abc	68.26fgh	69.36abc	60.43f	62.53h	62.53h	60.66k	61 .851
G19	65.81f-i	67.67ef	69.32a-d	68.70d-g	67.64ef	62.42d	64.43ef	64.43ef	64.75fg	64.34ghi
G20	65.23i	68.52b-e	68.48def	68.llfgh	67.44f	61.53e	64.04fg	64.06fg	63.42h	65.48de
G21	65.70f-I	67.53f	67.37g	68.84d-g	68.47cde	59.50g	61.651	61.651	63.79h	64.03hi
Kanchan	66.08e-i	68.84bc	69.58ab	68.87d-g	68.74cd	62.72d	63.78g	63.78g	67.26a	66.83ab
CV(%)			0.8					0.5		

In a column, means followed by a common letter are not sinific-ant1y different at the 5% level by DMRT.

Table 3. Mean values of pore length (µm) of both adaxial and abaxial surface *of leaf in twenty one near isogenic lines along* with a *check variety* Kanchan of wheat *(Triticum aestivum* L.) in different irrigations (I)

Genotypes (G)	Adaxial surface					Abaxial surface				
	Irrigation (I)					Irrigation (I)				
	Control	I_1	I_2	I_3	I_4	Control	I_1	I_2	I_3	I_4
G1	5.63b-f	5.84bc	5.95cde	5.86bcd	5.62c-f	6.16d	6.48cde	6.49cde	6.36c-f	6.34de
G2	5.71bf	6.33b	6.03b-e	6.22bc	6.06a-e	6.24cd	6.52cde	6.21d-h	6.31c-f	6.48bcd
G3	5.46def	6.03bc	5.92cde	5.77cde	5.95b-e	7.20a	7.45a	7.41a	741a	7.34a
G4	5.50c-f	6.24b	6.07b-e	6.27bc	6.lla-d	5.79de	6.69efg	6.42e-g	6.58bcd	6.54bcd
G5	5.78b-f	6.08bc	6.04b-e	6.22bc	6.05b-e	6.24cd	6.69bcd	6.63bcd	6.30c-f	6.44b-e
G6	5.85b-e	6.34b	6.16a-d	6.08bc	6.23ab	6.09d	6.35d-g	6.47c-f	6.59bcd	6.39cde
G7	5.68b-f	5.82bc	6.02b-e	6.l0bc	6.l8abc	6.75ab	6.92bc	6.98ab	6.89b	6.87abc
G8	5.85b-e	6.08bc	6.02b-e	6.04bcd	6.l4abc	6.08d	6.37d-g	6.53bcd	6.5lbcd	6.36de
G9	6.08bc	6.00bc	6.06b-e	5.85bcd	593b-e	6.07d	6.26d-g	6.14d-h	6.16d-g	6.l2def
G10	5.79b-f	5.95bc	5.6ldef	6.09bc	6.l7abc	6.20d	6.32d-g	6.39c-h	642bcd	6.03def
G11	5.99bcd	6.20b	5.92cde	5.7lcde	6.l3abc	6.20d	6.27d-g	6.45c-g	6.34c-f	6.40cde
G12	5.50c-f	5.59c	5.36f	6.02bcd	6.l7abc	6.05d	6.24d-g	6.38c-h	6.08d-g	6.30de
G13	5.65b-f	6.21b	6.33abc	6.08bc	6.l9abc	6.24cd	6.27d-g	5.96fgh	6.lld-g	6.37cde
G14	5.94b-e	6.03bc	5.98cde	6.99a	6.l3abc	6.16d	6.33d-g	6.24c-h	6.37cde	6.4lcde
G15	6.74a	7.lla	6.64a	5.49de	6.64a	6.28cd	6.30d-g	6.23d-h	6.34c-f	6.27def
G16	5.36ef	5.60c	5.62def	6.07bc	5.52ef	5.76de	5.93fg	6.15d-h	5.67g	5.92efg
G17	5.64b-f	5.98bc	6.15a-e	6.40bc	5.85b-f	6.70bc	7.04ab	7.00ab	6.69bc	6.9lab
G18	6.llb	6.24b	6.58ab	5.27e	5.86b-f	5.54c	5.86g	5.97e-h	5.88efg	5.55g
G19	5.28f	5.57c	5.55ef	6.19bc	5.34f	6.88ab	7.03ab	6.75bc	6.89b	7.22a
G20	5.88b-e	6.l8bc	6.12a-e	6.05bcd	6.09a-e	5.85de	6.00efg	5.89h	5.86fg	5.80fg
G21	5.58b-f	5.8lbc	5.84c-f	6.39b	5.55def	5.87de	6.0lefg	5.93gh	5.78g	6.36de
Kanchan	5.69b.f	6.0lbc	6.l0a-e	6.20bc	6.40ab	6.19d	6.39def	6.35c-h	6.31c-f	6.37cde
CV(%)			5.1					4.2		

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

Table 4. Mean values of pore breadth (μm) of both adaxial and abaxial surface of leaf in twenty one near isogenic lines along with a check variety Kanchan of wheat *(Triticum aestivum* L) in different irrigations (I).

Genotypes (G)	Adaxial surface					Abaxial surface				
	Irrigation (I)					Irrigation (I)				
	Control	I_1	I_2	I_3	I_4	Control	I_1	I_2	I_3	I_4
G1	0.61g-k	0.64fgh	0.73ghi	0.63g	0.60j	0.66cde	0.64c-f	0.67fgh	0.64gh	0.68def
G2	0.61g-k	0.64fgh	0.7lhi	0.65g	0.6lij	0.60ef	0.6lef	0.70e-h	0.57h	0.62f
G3	0.63e-i	0.76cd	0.87cd	0.76def	0.74efg	0.63def	0.71a-e	0.82b-e	0.7lefg	0.79cd
G4	0.88b	0.85b	0.95ab	0.79c-f	0.85bc	0.72bcd	0.76abc	0.66gh	1.00ab	0.74c-f
G5	0.56j-m	0.61h	0.80d-g	l.03ab	0.68ghi	0.6ldef	0.62def	0.81b-e	0.9lbc	0.76cde
G6	0.55k1m	0.7lc-f	0.90bc	1.09a	0.7lfgh	0.59ef	0.74a-d	0.76d-g	1.02a	0.68def
G7	0.59i-l	0.66e-h	0.82c-f	0.76c-f	0.77def	0.61def	0.69a-e	0.81b-e	0.81c-f	0.68def
G8	0.54klm	0.63gh	0.85cde	0.83cd	0.63ij	0.57ef	0.64c-f	1.00a	0.74d-g	0.65df
G9	0.55k1m	0.63gh	0.79efg	0.79c-f	0.80b-e	0.57ef	0.62def	0.81b-e	0.78def	0.82c
G10	0.61g-k	0.69d-g	0.82def	0.78c-f	0.64hij	0.78b	0.68b-f	0.82bcd	0.85cd	0.73c-f
G11	0.70cde	0.72cde	0.84c-f	1.03ab	0.67ghi	0.98a	0.70a-e	0.86bcd	0.69fg	0.68def
G12	0.531m	0.60h	0.77fgh	0.84c	0.74efg	0.55ef	0.57f	0.82b-e	l.0lab	0.68def
G13	0.511m	0.67e-h	0.77fgh	0.8lcde	0.66hij	0.52f	0.64c-f	0.79c-f	0.82cde	0.96a
G14	0.76c	0.76cd	0.86cde	0.82cde	0.85bcd	0.76bc	0.79ab	0.90abc	0.75d-g	0.93ab
G15	0.73cd	0.62gh	0.8ldef	1.00b	0.97a	0.78b	0.69a-f	0.81b-e	0.70efg	0.95a
G16	0.63f-j	0.64fgh	0.80d-g	0.75ef	0.74efg	0.59ef	0.64c-f	0.76d-g	0.72efg	0.76cde
G17	0.64e-i	0.76cd	0.77fgh	0.78c-f	0.98a	0.65cde	0.74a-d	0.77d-g	0.75d-g	1.02a
G18	1.00a	1.15a	0.68i	0.98b	0.53k	0.75bc	0.69a-f	0.80b-e	0.72efg	0.69def
G19	0.67d-h	0.86b	l.0la	0.79c-f	0.78c-f	0.66cde	0.81a	0.9labc	0.68fg	0.84bc
G20	0.61h-k	0.76cd	0.86cde	0.8lcde	0.8lb-e	0.60def	0.73a-e	0.85bcd	0.82cde	0.82c
G21	0.68d-g	0.72cde	0.83c-f	0.73f	0.86b	0.64c-f	0.73a-e	0.64h	0.74d-g	0.95a
Kanchan	0.70c-f	0.77c	0.56cde	0.5lcde	0.77ef	0.65cde	0.75abc	0.92ab	0.74d-g	0.77cde
CV(%)	5.3					8.7				

In a column, means followed by a common letter are not significantly different at the 5% level by DMRT.

abaxial surface of the flag leaf showed no such significant difference in different genotypes of wheat grown at irrigated and rainfed conditions. The present results also agreed with the findings reported by Jones (1977). It was also found that stomatal frequency per unit area varied among twenty one Near Isogenic Lines and check variety Kanchan (Table 1). Similar results were reported by Kazemi *et al.,* 1978 and Naveem and Garskin, 1990 and they reported that the number of stomata per unit leaf area has been shown to vary among genotypes within species and to be under genetic control. In the present study, the results of stomatal frequency of flag leaf in both the surfaces revealed that the adaxial surface contained more stomata than that of abaxial surface. Similar results were also reported by Kumer *et al.* (1986) in wheat. In the present study, stomatal index was found to be decreased in rainfed condition and differed in different schedules of irrigation but not remarkable and not in any particular direction. It was also indicated that stomatal index were higher at upper surface than the lower (Table 2). These results are consistent with Volkenburgh and Davies (1977). The present fmdings indicated that the water stress was significantly influenced on stomatal index.

The mature stomatal apparatus consists of a lenticular pore with fine cuticular ledges and is surrounded by two kidney shaped guard - cells containing abundant chloroplast. Stomatal aperture is an important index of drought tolerance since most transpirational water loss occurs through open stomata. In addition with different physiological factors, among the environmental factor CO_2 concentration appear to play a major role inside changes of the stomatal pore. Stomatal pore length of different genotypes at different schedules of irrigation in both the surfaces of flag leaves were found to vary but the differences were not remarkable and not in any particular direction. On the other hand, it was observed that stomatal pore lengths were significantly decreased in both the surfaces at rainfed condition (Table 3). Markhart (1985) stated that stomatal characteristics, such as stomatal density, aperture size, sensitivity change in internal and external water status. The diffusion resistance of the epidermis to water vapour transfer is a function of stomatal density, as well as pore size. In contrast, Hack (1974) also reported that stomatal pore or the sub stomatal cavity may change in relation to the moisture status of the plant.

The present findings also revealed that stomatal pore breadth decreased significantly under rainfed condition in both the surfaces than the irrigated condition (Table 4). Volkenburh and Davies (1977) reported similar results in cotton and soybean leaves. Singh (1978) reported that increase soil moisture improved leaf area and width of stomata of rye and wheat. In contrast, Ahmed (1994) reported that the size of stomata decreased significantly with the degree of water stress imposed to wheat seedling. The responses of stomata to leaf water status and environment are important in regulating transpiration and photosynthesis. Shimshi and Ephart (1975) reported that wheat cultivars differed widely in their stomatal aperture under adequate moisture conditions. Sullivan and Eastin (1975) pointed out that one might expect higher leaf temperatures when stomata are closed: thus the species that close their stomata earlier when stressed must have greater heat tolerance mechanisms. Glovar (1959) also reported changes in stomatal response after repeated stress periods. Sullivan and Eastin (1975) pointed out the necessity of considering previous growth conditions when evaluating stomatal response to *water* stress. From the results of the present study, it may be assumed that yield may be decreased with the decrease of stomatal aperture as well as stomatal pore breadth at rainfed condition.

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