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LEAF ANATOMICAL CHARACTERS IN RELATION TO GRAIN YIELD OF WHEAT (*TRITICUM AESTIVUM* L.) CULTIVARS

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Abstract

An experiment was carried out to study the variability of leaf anatomical characters of wheat (*Triticum aestivum* L.) cultivars and their association with grain yields. Results indicated that in most of the cases cultivar differences were significant. In respect of 6th leaf anatomical characters, simple correlation coefficients indicated that most of the leaf anatomical traits had significant negative relation with grain yield whereas in respect of flag leaf anatomical traits, only the association between radial dimension of big xylem vessel and grain yield was significantly negative and the correlation between number of veins and grain yield was significantly positive.

Key words: Leaf anatomy, wheat, yield, correlation

Introduction

Yield is a function of the interactions among factors responsible for crop growth and depends on environment for expression of its potentialities. Indeed, in some cases plant growth and development is mostly related to photosynthetic, anatomical and enzymatic leaf traits (Ceulemans and Impens 1987, Lecain *et al*. 1989 and Fisher 1985). There are several reports which indicate that photosynthetic rate is correlated with leaf anatomical characters in a number of plants (Wilson and Cooper 1969, Dornhoff and Shibles 1976); Paul and Eagles 1988). Knowledge in this regard is very scanty. So, the present experiment was set up to find out variability of anatomical characters of wheat (*Triticum aestivum* L.) cultivars and their associations with grain yield.

Materials and methods

The experiment was conducted in the research field of the Department of Botany, University of Rajshahi, Bangladesh. Eight cultivars of wheat (Opata BL 1183, C 306, BAW 452, BAW 171, Pavon 76 and Barkat) were grown in a randomized block design with three replications. The field was prepared after repeated ploughing. Before sowing, basal doses of nitrogen (80 kg/ha); TSP (40 kg/ha) and MP (40 kg/ha) were added. The whole experimental field was divided into three main plots for three replications. Each replication was 8 m long and 8 m wide. There were 40 rows in each replication where cultivars were arranged (for one cultivar there were 5 rows). The row to row and plant to plant distance was 20 cm and 10 cm, respectively. Leaf anatomical characters were studied from the transverse sections of the sixth and flag leaves. Three leaf segments (2.5 cm from base portion of leaf) per replication per cultivar were fixed in acetic-alcohol fixative (3

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parts of 70% ethyl alcohol and 1 part glacial acetic acid). The transverse sections of the preserved leaf segments were cut with razors, stained with safranine, and examined under a research microscope. Measurements were taken with eye-piece oculometer and stage micrometer at magnification of 10 × (eye-piece) and 10 × (objective). The following anatomical measurements were taken: thicknesses of leaf, upper epidermis, lower epidermis, big motor cell, mesophyll tissue and numbers of vascular bundles per mm^2, number of veins per mm, tangential dimension of midrib vascular bundle, radial dimension of midrib vascular bundle, tangential dimension of big xylem vessel and radial dimension of big xylem vessel. Finally, anatomical characters were correlated with grain yield. Statistical analysis was performed by a statistical package named Irristat Version 3.1 to show the significant difference among means in the interaction tables.

Results and Discussion

Leaf anatomical characters, such as thickness of upper epidermis (TUE), thickness of lower epidermis (TLE), thickness of big motor cell (TBMC), thickness of leaf through midrib (TL), tangential dimension of midrib vascular bundle (TDMVB), tangential dimension of big xylem vessel (TDBXV), radial dimension of big xylem vessel (RDBXV), thickness of mesophyll tissue (TMT), number of veins per leaf (NV) and vascular bundle per mm (VB) of 6^{th} and flag leaves were studied. Results indicated that cultivar differences were significant for most of the cases except TBMC for flag leaf and NV for 6^{th} leaf. This revealed that with a few exceptions, the cultivars were significantly different for their leaf anatomical characters. Hossain and Paul (1987) studied some leaf anatomical characters of jute species and observed significant varietal differences in the number of epidermal cells per mm^2, cross-sectional areas of the epidermal and of the palisade parenchyma cells. Mean values (Table 1) indicated that the ranges of thickness of upper epidermis were comparatively narrow between the leaves.

Table 1. Mean values of anatomical characters of 6^{th} and flag leaves of eight cultivars of wheat.

Cultivar	Thickness of upper epidermis (mμ)		Thickness of lower epidermis (mμ)	
	6^{th} leaf	Flag leaf	6^{th} leaf	Flag leaf
Opata	21.45b	23.59ab	21.45bc	20.26ab
BL 1183	28.60a	20.26c	22.64b	16.64bc
C 306	26.22ab	21.45bc	21.45bc	21.21a
Kanchan	26.22ab	21.45bc	23.59ab	18.83bc
BAW 452	23.84b	25.03a	21.45bc	23.83a
BAW 171	21.45b	23.59ab	20.49c	25.03a
Pavon 76	24.55ab	22.45bc	21.45bc	21.45a
Barkat	28.60a	21.45bc	24.79a	21.45a
LSD at 5%	4.10	2.28	2.09	4.68

(Continued)

Table 1. Mean values of anatomical characters of 6th and flag leaves of eight cultivars of wheat.

Cultivar	Thickness of big motor cell (mμ)		Thickness of leaf through midrib (mμ)	
	6th leaf	Flag leaf	6th leaf	Flag leaf
Opata	57.20bc	54.82ab	457.57c	433.77b
BL 1183	81.05a	64.35a	767.67a	598.23a
C 306	58.63bc	58.39ab	514.80c	493.73b
Kanchan	63.43b	54.82ab	633.97b	424.10b
BAW 452	58.63bc	66.73a	552.93bc	538.63a
BAW 171	49.10c	58.77ab	541.03bc	538.63a
Pavon 76	64.40bc	54.82ab	524.30bc	514.80a
Barkat	58.63bc	54.97ab	538.63bc	438.53b
LSD at 5%	9.08	7.56	106.57	73.15

Cultivar	Tangential dimension of midrib vascular bundle (mμ)		Radial dimension of midrib vascular bundle (mμ)	
	6th leaf	Flag leaf	6th leaf	Flag leaf
Opata	71.50c	97.72c	104.90d	95.33c
BL 1183	126.30a	166.80a	147.80a	135.89a
C 306	100.10b	100.10c	119.20c	119.20ab
Kanchan	119.20a	81.30d	150.20a	102.48bc
BAW 452	107.30b	109.63b	133.50b	119.17ab
BAW 171	102.50b	109.67b	133.50b	116.80ab
Pavon 76	107.30b	114.40b	140.60ab	114.40ab
Barkat	116.30a	100.10c	145.40a	112.03ab
LSD at 5%	10.97	8.63	11.74	17.56

Cultivar	Tangential dimension of big xylem vessel (mμ)		Radial dimension of big xylem vessel (mμ)	
	6th leaf	Flag leaf	6th leaf	Flag leaf
Opata	29.80c	28.12bc	28.60c	28.60bc
BL 1183	42.90a	40.52a	40.52a	40.52a
C 306	35.80b	37.56ab	33.37bc	34.08b
Kanchan	40.53ab	33.37b	38.75ab	33.37b
BAW 452	39.60ab	35.75ab	39.56ab	34.56ab
BAW 171	35.80b	34.56ab	38.13ab	36.94ab
Pavon 76	40.03ab	35.75ab	42.90a	40.52a
Barkat	42.90a	42.42a	41.95a	42.90a
LSD at 5%	5.49	6.20	6.06	8.47

(Continued)

Table 1. Mean values of anatomical characters of 6th and flag leaves of eight cultivars of wheat.

Cultivar	Thickness of mesophyll tissue at maximum point(mμ)		No. of veins / leaf		Vascular bundle / mm	
	6th leaf	Flag leaf	6th leaf	Flag leaf	6th leaf	Flag leaf
Opata	171.60c	171.60b	35.67a	50.00a	4.03ab	3.58b
BL 1183	305.10a	195.43a	37.33a	41.67c	3.80b	3.34c
C 306	188.30c	204.97a	38.00a	39.33c	4.70a	3.69b
Kanchan	207.40b	200.20a	38.67a	47.3b	4.53a	3.94ab
BAW 452	188.30c	202.60a	34.67a	50.33a	3.73bc	3.28c
BAW 171	181.10c	195.43a	35.33a	51.00a	3.80b	4.03a
Pavon 76	207.70b	183.52ab	41.33a	40.67c	4.27a	3.71b
Barkat	207.40b	188.28ab	32.00a	48.67ab	3.43bc	3.48bc
LSD at 5%	18.09	13.61	-	3.75	0.46	0.25

Thickness of lower epidermis showed trends like thickness of upper epidermis. Maximum TLE was observed in Barkat for the 6th leaf and BAW 171 for the flag leaf. The minimum TLE was attained in BAW 171 for the 6th leaf and BL 1183 for the flag leaf. Comparatively greater ranges of variation were observed in thickness of big motor cell. Highest TBMC was attained in BL 1183 for the 6th leaf and BAW 452 for the flag leaf but the lowest TBMC was observed in BAW 171 for the 6th leaf whereas in the case of flag leaf it was obtained in Opata, Kanchan and Pavon 76 respectively. Ranges of thickness of leaf through midrib were great among the leaves of different positions of the cultivars. Thickness of leaf was less important (Hossain and Paul 1987). The ranges of tangential dimension of midrib vascular bundle showed higher variability among the leaves of different positions of the cultivars. Radial dimension of the midrib vascular bundle showed similar trend like TDMVB. Ranges of tangential dimension of big xylem vessel showed comparatively smaller variability between the leaves of different positions of the cultivars. Radial dimension of big xylem vessel showed similar variability like TDBXV. Thickness of mesophyll tissue showed comparatively greater variability.

The results of the present study indicated no clear patterns among the cultivars due to leaf position. There were no clear patterns of leaf position effects on leaf thickness and the mean cross-sectional areas of palisade and spongy parenchyma cells in sweet potato (Shamsuddin and Paul 1988). Number of veins showed comparatively less variability between the ranges for the different positioning leaves of the cultivars. Finally, the ranges of VB per mm showed little variability between the different positioning leaves of the cultivars. Fisher (1985) reported that major veins included not only the midveins and secondaries but also tertiary and quarternary veins. Decreasing vein size was accompanied by increasing direct contact between vascular and photosynthetic tissues. Minor veins, which were made up 86% of the total vein length, were completely surrounded by photosynthetic bundle sheath and mesophyll consisting of palisade and spongy parenchyma. The overall organization of tissues in the variegated leaves differed little.

Simple correlation coefficients between 6th leaf anatomical characters and grain yield (Table 2) revealed that TLE, TBMC, TL, TMT, TDMBV, RDMVB, TDBXV and RDBXV showed significant positive correlation with thickness of upper epidermis (TUE). Thickness of lower epidermis (TLE) showed significant positive correlation with TDMVB, RDMVB, TDBXV and RDBXV.

Table 2. Simple correlation coefficients between 6th leaf (upper diagonal) and flag leaf (lower diagonal) anatomical characters and grain yield.

	TUE	TLE	TBMC	TL	TMT	TDMBV	RDMBV	TDBXV	RDBXV	VB/mm	NV/leaf	
	Thickness of upper epidermis	Thickness of lower epidermis	Thickness of big motor cell	Thickness of leaf	Thickness of Mesophyll tissue	TDM of MRVB	RDM of MRVB	TDM of BXV	RDM of BXV	Vascular bundle / mm	No of veins / leaf	Grain yield
No.	1	2	3	4	5	6	7	8	9	10	11	12
1	-	0.646**	0.516**	0.614**	0.616**	0.731**	0.609**	0.705**	0.567**	0.022	-0.004	-0.4
2	0.684**	-	0.362	0.286	0.305	0.519**	0.558**	0.532**	0.446*	-0.264	0.084	-0.115
3	0.124	-0.054	-	0.672**	0.833**	0.469*	0.389	0.431*	-0.029	0.281	0.057	-0.488*
4	-0.037	-0.098	0.552**	-	-0.304	0.797**	0.704**	0.399	0.512*	0.065	0.226	-0.487*
5	-0.282	0.017	0.242	0.256	-	0.654**	0.568**	0.565**	0.418*	0.165	-0.073	-0.518**
6	0.099	0.072	0.427*	0.703**	-0.056	-	0.892**	0.893**	0.502*	0.063	0.047	-0.448*
7	-0.083	-0.039	0.435*	0.255	0.239	0.594**	-	0.810*	0.776**	0.034	-0.069	-0.489*
8	-0.339	-0.211	-0.084	0.028	0.045	0.303	0.512*	-	0.796**	0.127	-0.015	-0.434*
9	-0.197	0.134	-0.168	0.186	-0.136	0.409*	0.432*	0.726**	-	0.052	-0.185	-0.489*
10	-0.068	-0.003	-0.324	-0.323	-0.104	-0.318	-0.23	-0.374	-0.285	-	0.348	0.349
11	-0.033	0.278	-0.063	-0.295	-0.21	-0.206	-0.279	0.056	-0.191	-0.265	-	-0.181
12	0.389	0.179	0.089	-0.144	0.188	-0.185	-0.234	-0.167	-0.449	-0.207	0.441*	-

Thickness of big motor cell showed significant positive correlation with TL, TMT, TDMVB and TDBXV but they showed significant negative correlation with grain yield. Thickness of leaf through midrib (TL) showed significant positive correlation with TDMVB, RDMVB and RDBXV but the association between TL and grain yield was significantly negative. The correlation between thickness of mesophyll tissue (TMT) and grain yield was also significantly negative but it showed significant positive correlation with TDMVB, RDMVB, TDBXV, and RDBXV. Tangential dimension of midrib vascular bundle (TDMVB) showed significant positive correlation with RDMVB, TDBXV, and RDBXV but it also showed significant correlation with grain yield. Radial dimension of midrib vascular bundle (RDMVB) showed significant positive correlation with TDBXV and RDBXV but showed significant negative correlation with grain yield. Tangential dimension of big xylem vessel (TOBXV) showed significant positive correlation with RDBXV but showed significant negative correlation with grain yield. Finally the association between radial dimension of big xylem vessel (RDBXV) and grain yield also showed significant negative correlation. Most of the leaf anatomical characters showed significant correlation with grain yield except TUE and TLE. This revealed that the 6th leaf anatomical traits had no important relation with grain yield.

Correlation coefficients between flag leaf anatomical characters and grain yield (Table 2) revealed that the associations between TUE and TLE, TBMC and TL, TBMC and TDMVB, TBMC and RDMBV, TMT and TDMVB, TDMBV and RDMVB, TDBXV and RDBXV were significantly positive. This indicated that leaf anatomical traits had significant and important relation among themselves. Only the correlation between RDBXV and grain yield was significantly negative but the association between NV and grain yield was significantly positive. It revealed that number of veins per mm had important relation with grain yield. Yield per plant had greater relationship with flag leaf area, flag leaf sheath area, spike area, photosynthetic area and grains per spike suggesting that spike area and flag leaf sheath area were the most important yield contributing traits (Islam *et al*. 2000).

References

Ceulemans R and Impens I (1987) Variation in photosynthetic, anatomical and enzymatic leaf traits and correlations with growth in recently selected populus hybrids. *Can. J. For. Res.* **17**: 273-283.

Dornhoff G M and Shibles R M (1976) Leaf morphology and anatomy in relation to CO_2 – exchange rate of soybean leaves. *Crop Sci.* **16**: 377-381.

Fisher D G (1985) Morphology and anatomy of the leaf of *Coleus blumei* (Lamiaceae). *Amer. J. Bot.* **72**: 392-406.

Hossain S M A and Paul N K (1987) A comparative study in stomatal and leaf anatomical characters of two cultivated jute species (*Corchorus capsularis* L. and *Corchorus olitorious* L.). *Acta Agron. Hungarica* **36**: 231-236.

Islam M M, Hossain M T and Islam M A (2000) Interrelationships and path analysis in the component characters of photosynthetic area and yield in wheat. *Bangladesh J. Agril. Sci.* **27**: 91-94.

Lecain D R Morgan J A and Zerbi G (1989) Leaf anatomy and gas exchange in nearly isogenic semidwarf and tall winter wheat. *Crop Sci.* **29**: 1246-1251.

Paul N K and Eagles C F (1988) Cultivar differences in net photosynthetic rates and their relationship with leaf anatomical characters in *Brassica*. *Photosynthetica* **22**: 320-327.

Shamsuddin S A K and Paul N K (1988) Stomatal frequency, size and leaf anatomical characteristics of sweet potato as influenced by cultivar and leaf blade surface and position. *Rajshahi Univ. Studies* **26**: 41-49.

Wilson D and Cooper J P (1969) Effect of temperature during growth on leaf anatomy and subsequent light saturated photosynthesis among contrasting *Lolium* genotypes. *New Phytol*. **68**: 1115-1123.