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Genetic Variation and Heritability of Excised-leaf Water Loss and its Relationship with Yield and Yield Components of F_5 Bulks in Five Wheat Crosses

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Abstract: Excised-leaf water loss was studied in 50 F_5 bulk lines in five wheat crosses including their common parent. A wide range of variability for excised-leaf water loss recorded as 5.47 to 18.81% and 10.36 to 25.36% at 2 and 4 h after excision, respectively. Generally, the lines that higher water at 2 h after excision also losses higher at 4 h after excision. For excised-leaf water loss the heritability was very high ranging from 89.36 to 96.70% in the five crosses. The result suggested the involvement of additive genes in the control of excised-leaf water loss. In general a negative correlation was found between excised-leaf water loss and yield in all the crosses. Among the five crosses Kanchan x DSN-34 provided maximum high yielding lines with low excised-leaf water loss.

Key words: Excised-leaf water loss, F_5 bulk lines, entries, drought, heritability, genetic advance

Introduction

Wheat (***Triticum aestivum*** L.) is one of the most important crop ranking first in acreage and production among the crops of the world (FAO, 1998). In most of the developing countries this crop is grown under residual soil moisture. Lack of irrigation facilities, low and uneven rainfall and terminal heat stress during the wheat crop season reduces yield of whet grains (Razzaque and Hossain, 1991). Yield in wheat is the resultant factor of a number of inherent potentialities like growth periods and yield components. Water content of leaves also play an important role in the expression of these potentialities. It has been reported in literatures that water content of leaves influences yield through yield contributing characters. The assessment of water loss rate from excised-leaves has shown some promise of differentiating genotypic ability for better performance under adverse growing condition (Clarke and McCaig, 1982). Clarke (1983) observed significant differences in excised-leaf water retention capability in plants grown in field and controlled environment condition. In this study cultivar differences were clearly shown in stressed environments and leaves from non-stressed environment lost water than leaves from stressed environment. In the segregation population of a cross between cultivars with high and low water retention, Dedio (1975) suggested that water retention was simply inherited and that the ability of retaining water was controlled by dominant gene action. Measurement of excised-leaf water loss is a simple technique and needs to sophisticated technology (Clarke and McCaig, 1982). It is therefore, an important avenue of research to examine the use of this technique to identify wheat genotypes that might be better grown in water stressed environment. Considering the above facts the present study was undertaken to assess the performance of fifty F_5 bulk lines and a local cultivar 'Kanchan' for excised-leaf water loss and its relationship with yield and yield components of wheat crop.

Materials and Methods

The experiment materials consisted of fifty F_5 bulk lines obtained from five different crosses (10 lines from each cross) and one common parent, Kanchan of the crosses. These crosses were Kanchan × DSN-34, Kanchan × YC-17, Kanchan × YC-16, Kanchan × BW-115 and Kanchan × Ad-119. Seeds of F_5 bulk lines and their common parent 'Kanchan' were planted in a triplicated randomized complete block design at the Field Laboratory of the Department of Genetics and Plant Breeding, Bangladesh Agricultural University, Mymensingh, Bangladesh. Two-row plot of 2.5 m long was used for each F_5 bulk line buffered by a single row of their common parent, Kanchan. So, there are 11 entries (10 F_5 bulk lines and Kanchan) for each cross in each replication. Entries of each cross were grown separately in the adjacent plots. The distance between rows was 20 cm and that between plants in a row was 5 cm. At anthesis five fully expanded flag leaves taking one from main stem of each of the five plants were cut and sampled, 3 to 4 h after the sun rises. Samples were immediately taken to the laboratory and their fresh weights were taken. These leaves were wilted under room temperature (25°C) and humidity (75%) and their weights were taken after 2 h of wilting. These wilted leaves were further, allowed to the same environment of another 2 h and again their weights were taken, i.e., after 4 h of wilting. Finally, the leaves were placed in oven at 50°C temperature for 72 h and the oven dry weight of the leaf samples were recorded. Water loss at 2 and 4 h was measured from the initial water content minus the water content after 2 and 4 h of wilting, respectively. The excised-leaf water loss were expressed in percentage (%). At maturity 5 plants were randomly marked from the middle part of the two-row plot for each line and yield and yield components were recorded. A moving mean for yield and yield components of the common parent 'Kanchan' was used for comparison with the bulk lines.

Results and Discussion

The analysis of variance for leaf water loss at 2 and 4 h after excision, yield components and yield/plant manifested highly significant differences among the entries in five crosses. The variability and heritability of the studied characters are presented cross wise in Table 1-5. The result revealed that seven entries in Kanchan × DSN-34, six in Kanchan × YC-17, four in Kanchan × YC-16, two in Kanchan × BW-115 and four in Kanchan × Ad-119 means total of 23 F_5 bulk lines out of 50 showed significantly lower percentages of leaf water loss at 2 h after excision than their common parent Kanchan. The entries 40-R-26, 36-R-27, 33-R-5, 37-R-32 and 31-R-31 showed lowest performance for water losses in their respective crosses. On the other hand, there were a wide range of variability for leaf water loss at 4 h after excision. It was also observed that all the entries in the crosses Kanchan × DSN-34 and Kanchan × YC-17 showed significantly lower after water loss at 4 h than the check parent. In the remaining three crosses, eight entries in

Table 1: Mean performance, heritability and genetic advance for excised-leaf water loss, yield and yield components of the cross Kanchan x DSN-34

F_5 bulk lines/check	Excised-leaf water loss (%) at 2 h	at 4 h	Spikes plant^{-1} (No.)	Spikelets spike^{-1} (No.)	Grains spike^{-1} (No.)	100-grain weight (g)	Yield plant^{-1} (g)
40-R-32	10.79c	16.67c	6.00cd	19.80bc	51.92d	4.17e	8.53
40-R-31	8.71d	13.48f	5.93cde	21.00a	63.20b	4.63bc	12.07
40-R-28	8.17de	15.48de	6.20bcd	20.53ab	61.53b	4.30de	14.27
40-R-26	5.47g	14.42ef	6.40bc	19.53bcd	56.53c	4.43bcd	13.00
40-R-24	11.78b	16.54cd	6.80b	18.87cd	41.30f	4.18e	9.73
40-R-21	7.40ef	10.36h	5.53de	20.13ab	63.27b	4.52bcd	11.87
40-R-15	14.73a	19.14b	7.53a	18.87cd	40.40f	4.86a	10.93
40-R-11	8.81d	14.33ef	6.53bc	18.67d	44.13e	4.67ab	9.73
40-R-9	6.58f	12.15g	6.20bcd	20.47ab	67.40a	4.66abc	15.13
40-R-1	12.68b	18.39b	5.87cde	16.53e	39.33f	4.46bcd	8.20
Kanchan (Check)	12.17b	20.48a	5.27e	20.23ab	39.03f	4.42cd	8.15
Mean±SE	9.75±0.32	15.59±0.38	6.21±0.22	19.51±0.31	51.46±0.8	4.48±0.07	11.06±0.3
CV%	5.63	4.23	6.15	2.72	1	2.78	6
Heritability	96.44	95.48	69.58	83.90	2.73	71.93	5.56
%					98.41		93.84
Genetic advance	59.29	39.09	16.00	11.68		7.89	
%					43.93		43.33

Table 2: Mean performance, heritability and genetic advance for excised-leaf water loss, yield and yield components of the cross Kanchan x YC-17

F_5 bulk lines/check	Excised-leaf water loss (%) at 2 h	at 4 h	Spikes plant^{-1} (no.)	Spikelets spike^{-1} (no.)	Grains spike^{-1} (no.)	100-grain weight (g)	Yield plant^{-1} (g)
33-R-32	12.92ab	17.16b	4.77cd	19.37de	47.27bc	4.45b	8.13b
33-R-31	13.45a	18.45b	5.87a	20.07bcd	29.57f	4.85ab	5.87d
33-R-27	7.98f	13.01e	6.20a	20.87ab	48.00b	4.49b	10.00a
33-R-25	9.13e	18.62b	3.33f	20.27bcd	45.00cd	3.80c	3.87f
33-R-23	12.62ab	17.21c	3.00f	18.67e	11.93h	5.12a	2.77g
33-R-20	10.52d	15.49d	1.57g	20.73abc	12.53h	4.75ab	2.57g
33-R-14	11.47c	18.56b	4.27e	20.93ab	25.47g	5.08a	4.47f
33-R-10	8.67ef	15.51d	5.00bc	21.77a	43.00d	4.69ab	7.33c
33-R-6	10.27d	16.30cd	5.10bc	20.80ab	54.20a	4.74ab	8.60b
33-R-3	10.41d	15.72d	4.60de	19.40a	43.00d	4.63b	5.20e
Kanchan (check)	12.17bc	20.48a	5.27b	20.23ab	39.03e	4.42b	8.15b
Mean±SE	10.87±0.29	16.96±0.40	4.45±0.13	20.28±0.41	36.25±0.78	4.64±0.13	6.09±0.22
CV%	4.60	4.11	5.00	3.50	3.74	4.87	6.24
Heritability %	92.75	89.26	97.31	54.44	99.11	69.10	97.76
Genetic advance %	32.63	23.04	61.41	5.80	81.39	12.47	83.79

Table 3: Mean performance, heritability and genetic advance for excised-leaf water loss, yield and yield components of the cross Kanchan x YC-16

F_5 bulk lines/check	Excised-leaf water loss (%) at 2 h	at 4 h	Spikes plant^{-1} (no.)	Spikelets spike^{-1} (no.)	Grains spike^{-1} (no.)	100-grain weight (g)	Yield plant^{-1} (g)
33-R-24	9.55e	16.55de	5.13ef	21.47a	42.07c	3.85d	7.43
33-R-23	9.32e	13.88f	5.87ab	20.87ab	16.27g	4.73ab	5.47
33-R-22	12.37bc	17.04de	5.40bcde	21.47a	15.80a	4.75ab	9.60
33-R-20	11.83c	18.81bc	5.20def	20.00ab	22.80f	4.35bc	4.33
33-R-17	12.99bc	19.70ab	5.67abcd	20.67ab	48.47b	4.74ab	9.60
33-R-15	10.56d	16.31e	5.43bcde	18.87d	47.93b	4.43bc	9.60
33-R-13	13.23b	17.19de	6.07a	20.40abc	91.87f	5.12a	4.73
33-R-10	11.41cd	17.96cd	4.43g	19.33cd	25.00e	4.05cd	4.63
33-R-9	15.92a	20.14ab	5.73abc	20.13bc	15.60g	4.96a	2.87
33-R-5	8.33f	14.44f	4.80fg	21.13ab	48.40b	4.50b	8.27
Kanchan (check)	12.17c	20.48a	5.27cdef	20.23bc	39.03d	4.42bc	8.15
Mean±SE	11.54±0.32	17.50±0.50	2.36±0.16	20.50±0.34	34.48±0.17	4.54±0.13	6.79±0.29
CV%	4.85	4.93	5.22	2.83	3.49	4.77	7.26
Heritability %	93.19	85.89	71.21	63.18	99.28	72.78	96.06
Genetic advance %	35.60	23.20	14.81	6.10	84.56	13.70	72.45

Table 4: Mean performance, heritability and genetic advance for excised-leaf water loss, yield and yield components of the cross Kanchan x BW-115

F_5 bulk lines/check	Excised-leaf water loss (%) at 2 h	at 4 h	Spikes plant^{-1} (no.)	Spikelets spike^{-1} (no.)	Grains spike^{-1} (no.)	100-grain weight (g)	Yield plant^{-1} (g)
33-R-32	10.55f	18.45d	6.67bc	21.87a	53.53a	4.55a	11.93a
33-R-29	12.35d	16.77f	6.00de	21.47ab	53.93a	3.28b	8.67c
33-R-28	16.71a	23.97a	6.90ab	18.67e	32.90e	4.29a	7.00d
33-R-27	14.43b	20.19bc	6.93ab	20.53bc	42.33c	4.45a	8.73c
33-R-23	11.12f	20.58b	5.33fg	21.87a	34.70e	4.73a	7.47cd
33-R-15	11.20ef	17.72ef	5.88eef	18.67e	28.60f	4.55a	5.60e
33-R-10	12.62cd	19.11cd	5.67efg	19.27de	43.60bc	3.45b	7.27d
33-R-8	13.67bc	19.55bcd	6.33cd	20.87abc	45.33d	4.72a	10.47b
33-R-3	13.07cd	19.98bc	5.33fg	20.67bc	53.47a	4.31a	10.13b
33-R-1	12.96cd	20.34b	7.27a	18.80e	33.00e	4.64a	10.27b
Kanchan (check)	12.17de	20.48b	5.27g	20.23cd	39.03d	4.42a	8.15cd
Mean±SE	12.81±0.33	19.74±0.37	6.13±0.16	20.26±0.35	41.86±0.80	4.31±0.15	8.69±0.42
CV %	4.46	3.24	4.49	2.95	3.29	6.02	8.26
Heritability %	89.72	89.07	86.52	79.97	97.73	76.49	86.38
Genetic advance %	25.85	17.99	22.23	10.87	44.05	19.52	39.66

Table 5: Mean performance, heritability and genetic advance for excised-leaf water loss, yield and yield components of the cross Kanchan x Ad-119

F_5 bulk lines/check	Excised-leaf water loss (%) at 2 h	at 4 h	Spikes plant^{-1} (no.)	Spikelets spike^{-1} (no.)	Grains spike^{-1} (no.)	100-grain weight (g)	Yield plant^{-1} (g)
33-R-31	9.61h	15.90e	4.00f	19.87a	48.93a	4.48d	8.13de
33-R-29	18.81a	25.36a	5.47d	20.00a	40.15ef	4.59cd	8.93cd
33-R-28	17.00b	22.70b	6.60b	17.80bcd	34.13g	4.51d	8.80cd
33-R-24	14.25cd	19.84cd	4.70e	18.13bcd	44.30bcd	4.71abcd	8.53cde
33-R-23	11.13g	18.89d	6.67b	17.20d	48.80a	4.94ab	11.80a
33-R-21	13.07e	23.36b	4.47e	17.73cd	4247.0cde	4.88abc	8.07de
33-R-20	13.64de	21.03c	5.60d	20.13a	35.73g	4.95a	7.07e
33-R-17	10.74g	14.69e	6.14c	18.80b	55.40bc	4.89abc	9.80bc
33-R-9	14.72c	23.09b	6.13c	19.80a	41.87def	4.61bcd	9.00cd
33-R-2	10.85g	15.88e	8.27a	18.67bc	46.53ab	4.62abcd	11.20ab
Kanchan (check)	12.17f	20.48c	5.27de	20.23a	93.03f	4.42d	8.15de
Mean±SE	13.27±0.30	20.11±0.47	5.76±0.15	18.94±0.32	42.49±0.95	4.69±0.11	9.04±0.49
CV %	3.90	4.03	4.49	2.95	3.87	3.72	9.43
Heritability %	96.70	94.82	95.47	78.37	89.62	42.28	70.33
Genetic advance %	42.74	34.43	41.57	10.23	22.19	5.11	25.07

Table 6: Relationship of excised-leaf water loss at 2 and 4 h with yield and yield components in five crosses

Crosses	Spike plant^{-1}	Spikelets plant^{-1}	Grains spike^{-1}	100-grain weight	Yield plant^{-1}
Kanchan x DSN-34	0.62 (0.16)	-0.51** (-0.37*)	-0.77** (-0.78**)	0.03 (-0.13)	-0.61** (-0.61**)
Kanchan x YC-17	-0.07 (-0.11)	-0.51** (-0.20)	-0.38* (-0.09)	0.32 (-0.12)	-0.19 (-0.17)
Kanchan x YC-16	0.35* (0.03)	-0.24 (-0.04)	-0.36* (-0.06)	0.48** (0.04)	-0.40* (-0.14)
Kanchan x BW-115	0.40* (0.22)	-0.43* (-0.31)	-0.17 (-0.43*)	-0.12 (0.28)	-0.12 (-0.10)
Kanchan x Ad-119	-0.02 (-0.19)	-0.07 (-0.07)	-0.67** (-0.63**)	-0.17 (-0.12)	-0.27 (-0.35*)

Figures in parenthesis indicate 'r' value at 4 h.

Table 7: High yielding F_5 bulk lines of four crosses and their excised-leaf water loss at 2 and 4 h

Cross/Check	F_5 bulk lines	Yield plant^{-1} (g)	Excised-leaf water loss (%) after excision at 2 h	at 4 h
Kanchan x DSN-34	40-R-9	15.30	6.50	12.15
	40-R-28	14.27	8.17	15.48
	40-R-26	13.00	5.47	14.42
	40-R-31	12.07	8.71	13.48
	40-R-21	11.87	7.40	10.36
Kanchan x YC-17	36-R-27	10.00	7.98	13.01
Kanchan x BW-115	37-R-32	11.93	10.55	18.45
Kanchan x Ad-119	31-R-23	11.80	11.13	18.89
	31-R-2	11.20	10.85	15.88
Kanchan (check)	--	8.15	12.17	12.48

Kanchan × YC-16, four in Kanchan × BW-115 and another four in Kanchan × Ad-119 also showed significantly lower water loss than the check parent. The lines 40-R-21, 36-R-27, 33-R-23, 37-R-29 and 31-R-17 showed lowest performance for this character in their respective crosses. As the maximum entries showed lower performance for water loss at 4 h, the result indicated that some of the F_5 bulk lines might be drought tolerant and further evaluation in necessary to identify them. Because water loss was found to be negatively correlated with yield in some studies (Clarke ***et al.***, 1990; Ma ***et al.***, 1998) in drought condition. Premachandra and Shimada (1988) found significant differences in leaf water loss at 10 to 24 h after excision in 12 spring and 12 winter wheat cultivars. Balota (1995) also found significant differences between genotypes for water loss after 5 h of dehydration. Very high heritability along with very high genetic advance for leaf water loss at 2 and 4 h after excision were observed in Kanchan × DSN-34 followed by Kanchan × Ad-119. Other crosses also showed high heritability and moderate to high genetic advance for leaf water loss both at 2 and 4 h after excision. The result indicated that the expression of this character was predominantly controlled by the additive gene effects, Similar to this findings, Dhanda and Sethi (1988) reported that additive gene action played a major role in determining the inheritance of excised-leaf water loss in F_1 generation of wheat crosses. Therefore, selection for lower water loss would be highly effective in the material used in present study. Twenty-three F_5 bulk lines out of 50 in different crosses produced significantly higher number of spike plant^{-1} than the check parent. Among them seven entries in both Kanchan × DSN-34 and Kanchan × BW-115, two in both Kanchan × YC-17 and Kanchan × YC-16 and five entries in Kanchan × Ad-119 gave significantly higher spike plant^{-1} than their common parent. Very high heritability and genetic advance for this trait was found in Kanchan × YC-17 and Kanchan × Ad-119. The result suggested that this character is controlled by additive gene action in these crosses. So direct selection for this character would be effective towards the improvement of this character in the said crosses. Other crosses also showed high heritability along with low to moderate genetic advance for this trait. Excised-leaf water loss at 2 h showed positive relation in two crosses. This result indicated that increase in spike number would increase water loss possibly due higher leaf surface of increased tiller number in these cross. In other crosses, the relationship is negative and negligible.

There were no entries in Kanchan × DSN-34 and Kanchan × Ad-119 showed higher spikelet number than the check parent. One in Kanchan × YC-17, two in Kanchan × YC-16 and three eateries in Kanchan × BW-115, i.e. a total of six entries were found to have significantly higher spikelets number than check parent. High heritability but low genetic advance were observed for this trait Kanchan × DSN-34, Kanchan × BW-115 and Kanchan × Ad-119.Other two crosses showed moderate heritability and very low genetic advance. These results indicated the involvement of both additive and non-additive genes for the control of this character. The relationship between excised-leaf water loss at 2 and 4 h and spikelets spike^{-1} was negative in all the crosses indicating the cross and it was significant in Kanchan × DSN-34. Also the relationship was significant in Kanchan × YC-17 and Kanchan × BW-115 for water loss at 2 h only. This result suggested that higher loss of water would be accomplished by reduced spikelet number.

The maximum mean grain number (51.64) was observed in the cross Kanchan × DSN-34. Seven eateries of this cross also showed significantly higher number of grain than the check parent. The line 40-R-9 of this cross produced highest number of grain (67.40) among all the eateries in five crosses indicating the cross Kanchan × DSN-34 was an obviously exception. Likewise six entries in Kanchan × Ad-119 also showed significantly higher grains spike^{-1} compared to the check parent. So, it has been observed that 30 eateries out of 50 F_5 bulk lines gave higher grains spike^{-1} than the crosses except moderate genetic advance in Kanchan × Ad-119. This result suggested that the character was highly heritable and therefore, selection for this character would give positive response towards the increase in grain number. Excised-leaf water loss showed negative correlation with grains spike^{-1} in all the cross Kanchan × DSN-34 and Kanchan × Ad-119. This result at least suggested that higher loss of water would decrease grains spike^{-1} possibly through the reduction in spikelet number.

Only 10 F_5 bulk lines were found to have significantly higher 100-grain weight than the check parent, but variability was observed for this character in all the crosses. Sharma ***et al.*** (1998), also observed moderate variability for 100-grain weight in some wheat genotype. The highest grain weight (5.12 g) was recorded in the entry 36-R-23 and 33-R-13 of Kanchan × YC-17 and Kanchan × YC-16, respectively. High heritability and moderate genetic advance was observed in cross Kanchan × BW-115. Other crosses showed moderately genetic advance was observed in the cross Kanchan × BW-115. Other crosses showed moderately high heritability but low to very low genetic advance. Moghaddam ***et al.*** (1998) also noted intermediate to moderate estimates of heritability and genetic advance of 100-grain weight which suggested that this character is partially effective for selection towards the increase in grain weight. Excised-leaf water loss showed very poor association (either positive or negative) with 100-grain weight in all crosses. There was a significant positive relationship between water losses at 2 h and grain weight in Kanchan × YC-16 which suggested that higher water loss would not decrease or hamper grain plumpness. A wide range of variation was observed for yield plant^{-1} in different crosses. In ranged from 8.15 to 15.13 g, 2.57 to 10.00 g, 2.87 to 9.60 g, 5.60 to 11.93 g and 7.07 to 11.80 g in Kanchan × DSN-34, Kanchan × YC-17, Kanchan × YC-16, Kanchan × BW-115 and Kanchan × Ad-119, respectively. Uddin ***et al.*** (1997) and Krishnawat and Sharma (1998) also observed a high range of variation for yield plant^{-1} in wheat. The cross Kanchan × DSN-34 contained maximum high yielding lines compared to check parent among the five crosses. The result showed that 19 F_5 bulk lines out of 50 were recorded as high yielded, in which eight entries of Kanchan × DSN-34, only one of Kanchan × YC-17, three of Kanchan × YC-16, four of Kanchan × BW-115 and another three of Kanchan × Ad-119. These results concluded that bulk selection was effective in identifying higher yielding lines in different crosses. Very high heritability and genetic advance was found for yield plant^{-1} in all the crosses except moderate heritability and genetic advance for grain yield plant^{-1} which showed conformity of the present finding. Therefore, the character was mainly controlled by additive genes and selection of this character would give positive response in the materials used. Excise-leaf water loss was found to have negative correlation with yield in all the crosses. However, such relationship was significant negative in Kanchan × DSN-34, Kanchan × YC-16 (Only for 2 h after excision) and Kanchan × Ad-119 (for 4 h after excision). There are plenty of confirmed reports which implies that higher rate of excised-leaf water loss decrease yield in wheat (Clarke and McCaig, 1982; Clarke and Townely-Smith, 1986; Clarke **et al.**, 1990).

In summary, the excised-leaf water loss trait was found to be heritable and predominantly controlled by additive gene effects. This trait was negatively correlated with yield mainly due to the reduction of spikelets and grain number in a spike. However, nine entries gave higher yield but lower water loss compared to the common parent used as check of five crosses. The cross combination Kanchan × DSN-34 provided the opportunities for identifying high yielding lines with low excised-leaf water loss and high spike plant^{-1} and grains spike^{-1}.

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