INHERITANCE OF TOTAL LEAF AREA AND LEAF GROWTH HABIT AND THEIR RELATIONSHIP TO GRAIN AND STRAW YIELD IN SOME WHEAT CROSSES

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Four wheat crosses, 5671 × Japani, Nainari 60 × C228, C591 × Sonora 64, and Sonora 64 × C271 were analysed for the inheritance of leaf area with grain yield and straw weight. Droopy leaf growth was found to be dominant over erect growth in all the F_2s and appeared to be under a monogenic control. Total leaf area followed a quantitative pattern in all the four crosses, conditioned by a number of polygénes showing some dominance for narrow leaf area. Transgressive segregation was also observed. Total leaf area was shown to have strong positive association with grain and straw yield. It is proposed that the wheat breeders should keep this relationship in view while drawing up the plans for wheat improvement.

INTRODUCTION

Wheat, a leading source of the world food supply and staple food for people in West Pakistan, has lately become an object of intensive research seeking increased acre yields. However, in spite of this, certain areas in wheat research have remained largely neglected. As for instance, there exists a complete lack of understanding about the inheritance of total plant leaf area and leaf growth habit and their relationship with grain and straw yield. Information on such a relationship can be of immense value in standardizing plant types associated with maximum yield potential realizable under varying growth conditions.

It is a well established fact that total leaf area in plant has a direct relation with the total dry matter produced as reported by Watson (1958) on wheat; Brougham (1958-60), Black (1963), Davidson and Donald (1958) on clover; Wilfong *et al.* (1967) on alfalfa, and Williams *et al.* (1965) on maize.

Wheat stock maintained in the Department of Plant Breeding and Genetics, WPAU, Lyallpur comprises such varieties as show marked differences in leaf area, leaf colour, position of the terminal leaf, and leaf growth habit. These differences might play a vital role in developing the yield potential of wheat varieties. The present study was undertaken to find out the genetic basis for the differential development of the total leaf area in wheat varieties, on the one hand, and its correlation to grain and straw yield, on the other.

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MATERIALS AND METHODS

Seven wheat varieties, 5671, Japani, Nainari 60, C228, C591, Sonora 64 and C271 differing to a varying degree in total leaf area (Table 1) were used to produce the following four crosses for a study: 5671 × Japani, Nainari 60 × C228, C591 × Sonora 64 and Sonora 64 × C271. The F_1, F_2, and parental generations were grown in a randomised complete block design, with 4 replications. The seed was planted in rows one foot apart, thinning the plant population sometimes after germination to 20 uniformly spaced plants a row, keeping 10 plants each of the F_1 and parents and 80 plants each of the F_2 populations per replication. Thus a total of 320 plants of each F_2 and 40 plants each of the parents and F_1s were analysed.

The length and maximum width of each leaf were measured in centimetres and millimetres, respectively, at a stage when leaf had ceased to grow. Total leaf area was calculated by the random tiller TLA method described by Carleton and Foote (1965) as follows: TLA per plant = mean leaf area per tiller of a random sample of tillers per plant × number of tillers per plant $= \Sigma$ (LxW) per tiller x b x number of tillers per plant.

Where (LxW) = product of the length and maximum width of a leaf;

and b = mean coefficient of the leaf area for each leaf divided by the (LxW) product of that same leaf. Mean coefficient of the leaf area (b) was estimated to be 0.75 in wheat.

Leaf growth habit of these plants appeared to be classifiable into three phenotypes; erect, semi-erect and droopy. Erect and semi-erect were grouped together and the F_2 ratio was confirmed by a chi square test.

After making measurement on leaf for TLA, 20 leaves were selected at random from each parental variety and preserved in FAA solution. Freehand transverse sections were made from the mid portions of 5 preserved leaves chosen randomly for each parent. From these leaves, a total of 100 cells were measured for average width in microns under a microscope (10 × B × 45). The average number of parenchyma cells in a longitudinal plane was calculated by dividing the average leaf width with the average cell width.

Correlation coefficients between total leaf area and grain yield and total leaf area with straw weight were calculated by conventional statistical methods. TLA data of all the F_2 and parental populations were summarised in frequency distributions in Table 1.

RESULTS AND DISCUSSION

The data presented (Table 1) show that all the four F_1s had their mean TLA expressed midway between the respective parents, whereas the corresponding F_2 means were somewhat lower than the F_1 means. This indicated additive gene control for the expression of the TLA in all the four crosses, although dominance for narrow TLA was also evident to some extent.

Standard deviations and coefficients of variability for TLA in all the four F_2s were greater than the corresponding values of the parental and F_1 generations, indicating genetic basis for a part of the F_2 variation. As such, it should be possible to achieve genetic advance by selection for TLA in these crosses. But, in view of the relatively low standard deviation values obtained in the F_2s, response to selection would be rather slow. The F_2 frequency distributions (Table 1) showed nearly normal distributions for the TLA, although showed toward narrow TLA. This provides further evidence that the TLA inheritance was conditioned either by many genes involving variable degree of dominance or a few genes highly susceptible to environmental variation. In all the four crosses, transgressive segregation was also evident, indicating a likelihood of obtaining the desired segregates by transgressive breeding.

The data on the inheritance of leaf growth habit (Table 2) revealed a simple inheritance pattern for this character. The F_2 appeared to segregate into droopy and erect classes in the ratio of 3: 1, indicating a monogenic control. Economic utility, however, of these phenotypes remains to be determined.

Anatomical studies (Table 3) have shown that parental varieties differ markedly for the estimated cell number of the leaf chlorenchyma tissue in a longitudinal plane. Most parents used in this study, particularly Japani and C271, do not differ significantly for the leaf width; yet two different developmental mechanisms appear to operate in the leaf growth process in these varieties. It may be concluded from the cell number data that the varieties showing no difference in leaves' width, are different genetically.

The F_2 correlation data (Table 4) for all the four crosses have indicated strong positive phenotypic associations of TLA with grain yield and straw weight. It appears that the genetic elements controlling TLA also exert significant influence on the development of grain yield and straw weight. Whether the strongly correlated expression of these three characteristics was caused by genetic linkage or pleiotrotic gene effects was not ascertained. From this study it is apparent that other factors being equal, the varieties with greater TLA should be expected to outperform the ones with relatively small TLA and a breeder would be well advised to give due attention to this factor in working out his plans on wheat improvement.

TABLE 1.—*Means, standard deviation, coefficients of variability and frequency distributions for total leaf area in parenta F_1 and F_2 populations.*

Generation		Means in square deci-metres	S.D.	C.V%	Frequency distributions (total leaf area) 0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	Total
P_1	5671	.. 15.25	4.47	29.31	..	5	16	14	3	2	..	..	40
P_2	Japani	.. 16.32	4.87	29.80	..	4	16	13	6	1	..	..	40
F_1	5671 × Japani	.. 15.69	4.66	29.70	1	3	15	14	5	2	..	..	40
F_2	5671 × Japani	.. 11.11	5.71	51.39	33	154	72	35	16	8	2	1	320
P_1	Nainari 60	.. 11.45	3.80	33.18	3	15	12	10	..	..	..	..	40
P_2	C228	.. 16.86	4.60	27.28	..	4	10	16	8	2	..	..	40
F_1	Nainari 60 × 228	.. 14.10	5.04	35.74	2	10	13	12	2	1	..	..	40
F_2	Nainari 60 × C228	.. 12.54	6.006	47.85	28	107	99	57	18	5	4	2	320
P_1	Sonora 64	.. 11.50	3.63	31.57	3	13	16	8	..	..	..	..	40
P_2	C271	.. 13.81	2.73	19.77	..	7	21	12	..	..	..	..	40
P_1	Sonora 64 × C271	.. 12.15	3.42	28.14	2	13	18	6	1	..	..	..	40
F_2	Sonora 64 × C271	.. 11.57	4.91	42.35	21	129	107	46	14	2	4	..	320
P_1	C591	.. 16.66	3.59	21.54	..	3	13	18	6	..	..	..	40
P_2	Sonora 64	.. 11.50	3.63	31.57	3	13	16	8	..	..	..	..	40
F_1	C591 × Sonora 64	.. 13.98	4.46	31.90	2	10	14	11	3	..	..	..	40
F_2	C591 × Sonora 64	.. 11.19	5.40	48.25	24	144	101	31	12	4	4	..	320

TABLE 2.—*Observed and expected class frequencies in the F_2 generations of the four crosses for leaf growth habit.*

Cross	Observed class		Expected class		X^2 values	P.values
	Droopy	Erect	Droopy	Erect		
5671 × Japani	244	76	240	80	0.27	0.455
Nainari 60 × C288	232	88	240	80	1.06	1.074
C591 × Sanora 64	245	75	240	80	0.416	0.455
Sonora 64 × C271	248	72	240	80	1.06	1.074

TABLE 3.—*Average parenchyma cell width and estimated cell number per mean leaf width of the parental varieties.*

Name of variety	Average width of the leaf (mm.)	Average width of the cell in microns	Estimated cell numbers in average leaf width
5671	13.7	39.5	347
Japani	13.3	41.0	324
Nainari 60	13.9	37.0	378
C228	14.2	40.5	350
C591	14.8	44.5	333
Sonora 64	15.1	42.5	355
C271	13.3	48.0	277

TABLE 4.—*Phenotypic correlation coefficient of total leaf area with grain yield and straw weight in four wheat crosses.*

Crosses	Correlations	
	Total leaf area with grain yield	Total leaf area with straw weight
5671 × Japani	0.877**	0.9382**
Nainari 60 × C288	0.724**	0.8107**
Sonora 64 × C271	0.6874**	0.925**
C591 × Sonora 64	0.80**	0.96**

**Significant at 1% level.

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