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Environmental Response and Influence of Flag Leaf Area on Grain Protein Percentage and Yield in Bread Wheat

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Abstract: For this study ten genotypes of spring wheat (*Triticum aestivum* L.) developed at three different breeding institutes were evaluated for two years at nine locations in Pakistan and Azad Jammu and Kashmir for various interactions. Genotype-location, genotype-year and genotype-location-year interactions were found highly significant (P<0.01) for flag leaf area, grain protein percentage and grain yield. The magnitude of interaction variance components viz., σ^2_{gl}, σ^2_{gy} and σ^2_{gly} reflected that relative performance of genotypes for these characters was more inconsistent across the locations than years. Thus, testing of genotypes at more locations for evaluation of these characters seems more effective than testing over more years. Flag leaf area showed significantly positive association with grain yield at two locations and non-significant association with grain protein percentage at all locations, whereas grain protein percentage indicated significantly negative association with grain yield at two locations, however, degree of correlation was inconsistent over the locations. It revealed that under appropriate agro-ecological conditions, concurrent selection for high grain yield based on flag leaf area is possible, whereas increase in yield may reduce grain protein percentage. The results suggest that for the development of superior and adaptable varieties, effect of environmental factors such as temperature, precipitation and soil fertility and their interactions on the expression and relationship of these characters should be considered greatly in breeding programmes.

Key words: *Triticum aestivum* L, flag leaf area, grain protein percentage, grain yield, G x E interaction, correlation, concurrent selection

Introduction

One of the aims fundamental to all plant breeding programmes is to develop high yielding varieties showing adaptability under different agro-ecological conditions. It is very important for long term planning and making projections to achieve sustainability in agricultural production.

Leaf area is an indicator of potential grain yield (Voldeng and Simpson, 1967; Monyo and Whittington, 1973) and broader and long leaves give higher grain yield in wheat (Kyzlasov, 1987), however, yield increase has been accompanied by lower total protein percentage of the grain (Busch *et al.*, 1969). Such yield-protein inverse relationship has also been reported by several other investigators (Campana and Sempe, 1984; Levy and Feldman, 1989 and Millet *et al.*, 1988).

Since, these characters are multigenic in nature (Allard and Bradshaw, 1964), their expression can be changed by the soil and environmental factors (Cooke, 1984). These factors have long been recognized as an important source of variation in the expression of the genotypic characters (Yates and Cochran, 1938; Mather, 1949). Hence, for synthesis of well-adapted genotypes, an understanding of expression and association of various characters under a particular set of environment is necessary. It becomes more important for plant characters directly related to quality and production in cereals.

The present study therefore, investigates the magnitude of genotype-environment interaction and influence of flag leaf area on grain protein percentage and yield under local set of environments. The information so derived may be effectively exploited to further streamline the wheat improvement efforts in the country.

Materials and Methods

Ten commercial bread wheat genotypes developed at three ecologically different breeding centers were evaluated for two years at nine widely distributed climatically distinct locations in Pakistan and Azad Jammu and Kashmir. Experiments were conducted in randomized complete block design with three replications. Eighty-five grams seed of each genotype was used for a plot size of 1.5 x 5.0 meter with 25 cm row to row distance. There was no supplemental irrigation and normal tillage and cultural practices were adopted.

Flag leaf area was recorded at anthesis from the primary tillers of 20 consecutive plants in the middle four rows of each plot. For this purpose plants were tagged early in the season. The tallest and vigorous tiller of each plant was considered as primary tiller for taking observations. The central one meter square area of each plot was harvested to determine plot grain yield. Grain protein percentage was examined by Kjeltec Auto 1030 analyzer. Amount of nitrogen was calculated by the formula, Nitrogen % age = 1.401 x Normality of HCL x (m1 titrant-Blank/Sample weight. Protein contents were calculated by multiplying the percentage of nitrogen contents with protein factor, that is 5.7 for wheat. Three samples from each plot were analyzed with this procedure and average value was worked out.

The genotype-year (σ^2_{gy}), genotype-location (σ^2_{gl}) and genotype-year-location (σ^2_{gyl}) variance components were determined by factorial analysis of variance as mentioned by Johnson *et al.* (1955). Regression coefficient was determined as proposed by Eberhart and Russell (1966) and association among the characters was calculated with the help of the statistical method as stated by Gomez and Gomez (1987).

Results and Discussion

It is evident from the significant (P<0.01) values of genotype-location (σ^2_{gl}) genotype-year (σ^2_{gy}) and genotype-location-year (σ^2_{gly}) interactions (Table 1) that relative performance of genotypes for flag leaf area, grain protein percentage and grain yield is highly inconsistent across the locations as well as years. It suggests that genotypes need to be tested at more locations along with years for evaluation of these characters. Large σ^2_{gl} as compared to σ^2_{gy} and σ^2_{gly} reflects that performance of these characters was more inconsistent over the locations than years. Testing at more locations thus seems more effective than testing over more years as suggested by Saeed, *et al.* (1987).

In Table 2, positive association of regression coefficient with flag leaf area (r = 0.727), grain protein percentage (r = 0.385) and grain yield (r = 0.712) revealed that genotypes having more flag leaf area, high grain protein percentage and high grain yield were more sensitive to changing environment as suggested by Faris *et al.* (1981) The Fig. 1, 2 and 3 also indicates similar behavior.

The variation in the relationship of flag leaf area, protein percentage and grain yield at different locations (Table 3) reflected significant environmental effect on the performance of the genotypes. Significantly positive association of flag leaf area with grain yield at two out of nine locations indicates that grain yield can be increased by increasing flag leaf area under certain environments. Kyzlasov (1987) and Yassein *et al.* (1986) also observed positive correlation amongst these characters. The non-significant association between flag leaf area and grain

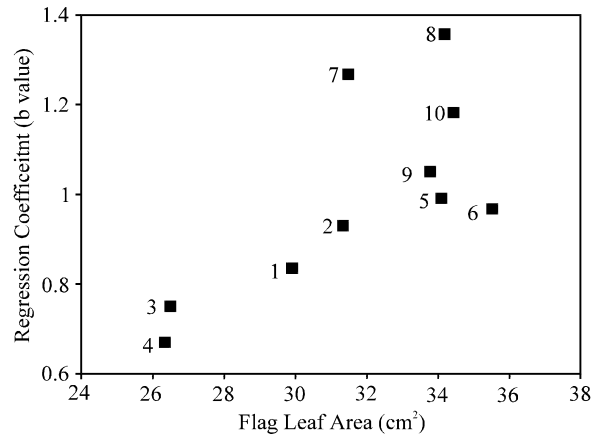


Fig. 1: Scattergram showing relationship of genotype adaptation (regression coefficient) and flag leaf area

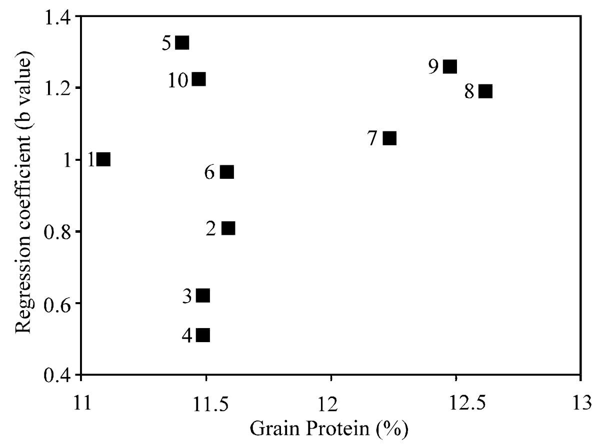
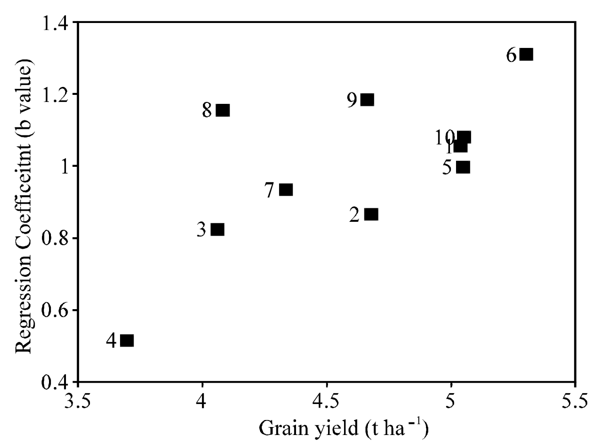


Fig. 2: Scattergram showing relationship of genotype adaptation (regression coefficient) and grain protein percentage



1P k 81 2 I 1 b 91 3 P b 90 4 R ht 90 5 Pi b k 85
6 Pirsabak 91 7 khyber 87 8 Soghat 90 9 Sind 81 10 Sarsabz

Fig. 3: Scattergram showing relationship of genotype adaptation (regression coefficient) and grain yield

Table 1: Analysis of variance for flag leaf area, grain protein percentage and grain yield

Source	df	Mean Square Flag leaf area (cm^2)	Grain protein (%)	Grain yield (t ha^{-1})
Year	1	2591.52**	24.25**	12.92**
Location	8	1388.83**	83.10**	28.72**
Genotype	9	704.70**	14.24**	15.26**
Genotype-Year	9	50.05**	1.83**	2.15**
Genotype-Location	72	74.89**	6.34**	2.56**
Genotype-Year-Location	72	53.82**	2.16**	1.60**
Error	324	0.97	0.01	0.05

** Significant at 1% level of probability

Table 2: Regression coefficient of flag leaf area, grain protein percentage and grain yield

Genotype	Flag leaf area (cm^2)	b_i	Grain protein (%)	b_i	Grain yield (t ha^{-1})	b_i
Pak 81	29.87e	0.83	11.09g	1.01	5.05 b	1.08
Inqilab 91	31.32d	0.93	11.59d	0.82	4.68c	0.86
Pasban 90	26.43f	0.75	11.49e	0.63	4.06e	0.82
Rohtas 90	26.26f	0.67	11.49e	0.51	3.70f	0.51
Pirsabak 85	34.13bc	0.99	11.41f	1.33	5.04b	1.02
Pirsabak 91	35.61a	0.97	11.59d	0.97	5.30a	1.32
Khyber 87	31.56d	1.27	12.25c	1.06	4.34d	0.93
Soghat 90	34.29bc	1.36	12.62a	1.19	4.08e	1.15
Sindh 81	33.83c	1.09	12.49b	1.26	4.66c	1.19
Sarsabz	34.55b	1.18	11.48 e	1.22	5.06 b	1.09
Correlation, r = 0.727			r = 0.358		r = 0.712	

Values followed by the same letter are not significantly different from each other by DMRT at 0.01 level of probability

Table 3: Correlation of flag leaf area, grain protein percentage and grain yield under different agro-ecological conditions

Location	Flag leaf area and grain yield	Flag leaf area and grain protein percentage	Grain yield and grain protein percentage
Islamabad	-0.01	0.16	-0.73*
Pirsabak	0.30	-0.46	0.03
Dera Ismail Khan	0.60	0.31	-0.09
Faisalabad	0.82**	0.49	-0.04
Chakwal	0.08	0.42	-0.21
Bahawalpur	0.68*	-0.31	-0.10
Tandojam	0.18	0.17	-0.11
Rawalakot	-0.03	0.47	-0.80**
Quetta	0.43	0.44	-0.21

* Significant at 5% level of probability, **Significant at 1% level of probability

protein percentage at all locations (Table 3) shows that selection for improvement of grain protein percentage can be exercised independent of flag leaf area. As flag leaf area significantly contributed to grain yield at some locations therefore, efforts to increase yield on the basis of flag leaf area, might result in reduction in grain protein percentage under certain environments which is clear from the significantly negative relationship between grain yield and grain protein percentage at two locations. In previous research studies, Campana and Sempe (1984), Levy and Feldman (1989) and Millet *et al.* (1988) also observed inverse relationship between yield and grain protein percentage.

The results suggest that due to the inconsistent relationship of these characters, selection for the improvement in grain yield on the basis of flag leaf area should not be exercised as a routine procedure as it may reduce grain protein percentage under certain environments. However, tendency of non-significant relationship of grain protein percentage with flag leaf area and grain yield is an encouraging fact. This reality give hope that the plant breeder will be able to minimize the inverse yield-protein percentage relationship in the development of future high yielding wheat varieties. However, investigation of the effects of the environmental factors on the development of these characters would help to understand their response to different environments and its utilization in breeding programmes for development of superior and widely adaptable varieties.

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