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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Science, 6 (4): 382-385, 2003
ISSN 1028-8880

Analysis of Variance and Influence of Number of Grains Per spike on Protein Percentage and Yield in Wheat Under Different Environmental Conditions

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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 year at nine locations in Pakistan and Azad Jammu and Kashmir. Genotypes x location, genotype x year and genotype x location x year interactions were found highly significant ($P<0.01$) for number of grains per spike, grain protein % and grain yield. Relative magnitude of interaction variance components viz., σ^2_{gl}, σ^2_{gy} and σ^2_{gly} reflected that relative performance of genotypes for grain protein percentage and grain yield was more inconsistent across the locations than years and opposite was true for number of grains per spike. Correlation amongst these characters showed positive association of number of grains per spike with grain yield, whereas grain protein percentage indicated negative associated with number grains per spike and grain yield under certain environments, however effect was inconsistent. It revealed that under appropriate agro-ecological conditions, concurrent selection for high grain yield based on number of grains per spike is possible, whereas increase in yield may reduce grain protein percentage. The results suggest that for breeding superior varieties, effect of environmental factors such as temperature, precipitation ans soil fertility and their interactions on the development of these characters and their relationships should be considered greatly in breeding programmes.

Key words: Spring bread wheat, number of grains, grain protein percentage, grain yield, G x E interaction, inter-relationship, concurrent selection

Introduction

An understanding of association of various characters under a particular set of environment is necessary of synthesis of well-adapted genotypes. This becomes very important for plant characters directly related to quality and production, such as number of grains per spike, grain protein percentage of grain yield in cereals.
The semi dwarf varieties have significantly increased the yield potential of wheat (*Triticum aestivum* L., em Thell.) mainly through their better lodging resistance and greater sink size. The yield increase, however, has been accompanied by lower total protein percentage of the grain, which in turn, lowers water absorption capacity of the flour and reduces the loaf of the dough (Busch *et al.*, 1969). This tendency among the wheat varieties is of critical concern both nutritionally and economically.
Previous research has indicated that the greater sink size of semi dwarf varieties is due to their producing more spikes ha^{-1}, more spikelets/spike and more grains/spike than normal tall cultivars (McNeal *et al.*, 1972; Johnson *et al.*, 1966). McNeal and Davis (1966) observed that grains from the top third of the spike were significantly lower in protein percentage than those of the bottom and middle parts. This suggests that the supply of nitrogenous products needed for protein production may become limited before the additional grains produced by the high yielding varieties mature.
The tendency for lower grain protein percentage in high yielding varieties does not result from undesirable linkages involving the dwarfing gene, but from inverse yield-protein relationship (Pepe and Heiner, 1975). Such yield-protein relationship has been reported by many investigators (Campana and Semp, 1984; Levy and Feldman, 1989; Millet *et al.*, 1988). As yield increase is accompanied by more grains per spike (Camargo, 1987; Li, 1989; Mikheev, 1992), the inverse relationship among number of grains per spike and grain protein percentage has been reported by Mahmood and Shahid (1993) and Wells (1984).
These relationships may change because of the changes in gene expressions that may occur due to the variations in environments. These changes known as genotype-environment interactions, have long been recognized as an important source of variation in the expression of the genotypic characters (Yates and Cochran, 1938; Mather, 1949). It has been found empirically that a linear relation frequently exists between character and environment (Finlay and Wilkinson, 1963) which accounts for most of

the variation in genotypic character over environments (Breese, 1969; Jinks and Perkins, 1970). Though several scientists have studied this phenomenon, the information on the subject under local environments is still inadequate. In the present study it is tried to determine the magnitude of relationship of number of grains per spike with grain protein percentage and yield under different environments.

Materials and Methods

Ten commercial bread wheat genotypes developed at three ecologically different wheat breeding centers were evaluated for two years at nine widely distributed climatically distinct locations in Pakistan and Azad Jammu and Kashmir during 1995-96 and 1996-97. Experiments were conducted in randomized complete block design with three replications and 85 g seed of each genotype was used for a plot size of 1.5x5.0 m^2 with 25 cm row to row distance. There was no supplemental irrigation and normal tillage and cultural practices were adopted.

Grains per spike were recorded at maturity from the spikes of 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 the primary tiller for taking observations. The centre 1 meter square area of each plot was harvested to determine plot grain yield (converted to t ha^{-1} at 15% moisture level). Grain protein percentage was examined with Kjeltec Auto 1030 analyzer. Amount of nitrogen was calculated by the formula, Nitrogen%= 1.401 x Normality of HCL x (ml 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 x year (σ^2_{gy}), genotype x location (σ^2_{gl}) and genotype x year x location (σ^2_{gyl}) variance components were determined by factorial analysis of variance as mentioned by Johnson *et al.* (1995). Regression coefficient was determined as proposed by Eberhart and Russell (1966) and association among the characters was calculated with the help of satistical method, as stated by Gomez and Gomez (1987).

Results and Discussion

Table 1 indicated that relative performance of genotypes for all characters is quite inconsistent across the locations as well as years. It suggests that genotypes need to be tested at more locations and years for evaluation of these characters. Large σ^2_{gl} as compared to σ^2_{gy} for grain protein percentage and grain yield 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 for evaluation of relative performance of these characters. Large σ^2_{gy} as
relative performance of these characters. Large σ^2_{gy} as
compared to σ^2_{gl} in case of grains per spike indicates that performance of this character is more inconsistent across the years than locations. However, as suggested by Saeed and Francis (1984), it would be possible to replace higher number of environments through different agronomic practices such as early and late planting at various locations for an additional year of testing without decreasing the precision of estimating a genotype (Table 2).

Positive association of regression coefficient (b_i) with

Table 1: Analysis of variance for number of grains per spike, grain protein percentage and grain yield

		Mean Square		
Source	df	Number of grains per spike	Grain progein (%)	Grain yield (t ha^{-1})
Year	1	684.94**	24.25**	12.92**
Location	8	2160.01**	83.10**	28.72**
Genotype	9	1094.05**	14.24**	15.26**
Genotype-year	9	224.26**	1.83**	2.15**
Genotype-Location	72	205.93**	6.34**	2.56**
Genotype-Year-Location	72	140.64**	2.16**	1.60**
Error	324	3.13	0.01	0.05

Table 2: Regression coefficeint of number of grains per spike, grain protein percentage and grain yield

Genotype	Number of grains per spike	b_i	Grain protein (%)	b_i	Grain yield (t ha^{-1})	b_i
Pak 81	58.35c	1.28	11.09g	1.01	5.05b	1.08
Inqilab 91	52.38e	0.92	11.59d	0.82	4.68c	0.86
Pasbab 90	51.56e	0.87	11.49e	0.63	4.06e	0.82
Rohtas 90	50.15f	0.68	11.49e	0.51	3.70f	0.51
Pirsabak 85	57.85c	1.16	11.41f	1.33	5.04b	1.02
Pirsabak 91	60.50b	1.27	11.59d	0.97	5.30a	1.32
Khyber 87	50.00f	1.02	12.25c	1.06	4.34d	0.93
Soghat 90	52.02e	1.04	12.62a	1.19	4.08e	1.15
Sindh 81	54.40d	0.92	12.49b	1.26	4.66c	1.19
Sarsabz	62.50a	0.84	11.48e	1.22	5.06b	1.09
Correlation	r = 0.474		r = 0.358		r = 0.712	

Table 3: Correlation of number of grains per spike, grain protein percentage and grain yield under diffrent agro ecological conditions

Location	Number of grains per spike and grain yield	Number of grains per spike and grain protein percentage	Grain yield and grain protein percentage
Islamabad	0.53NS	-0.25	-0.73*
Pirsabak	0.92**	-0.15	0.03
Dera Ismail Khan	0.94**	-0.03	-0.09
Faisalabad	0.90**	0.03	-0.04
Chakwal	0.92**	-0.28	-0.21
Bahawalpur	0.75*	0.15	-0.10
Tandojam	0.85**	-0.28	-0.11
Rawalakot	0.67*	-0.64*	-0.80**
Quetta	0.71*	-0.52	-0.21

*, ** Significant at 0.05, 0.001

number of grains per spike (r = 0.474), grain protein percentage (r = 0.358) and grain yield (r = 0.712) revealed that genotypes having more number of grains, high grain protein percentage and high grain yield were more sensitive to changing environments (Fig. 1, 2, 3) as suggested by Faris *et al.* (1981). Hence, consistency in the performance of these characters may by in those genotypes possessing relatively less number of grains per spike, less protein percentage and low grain yield.

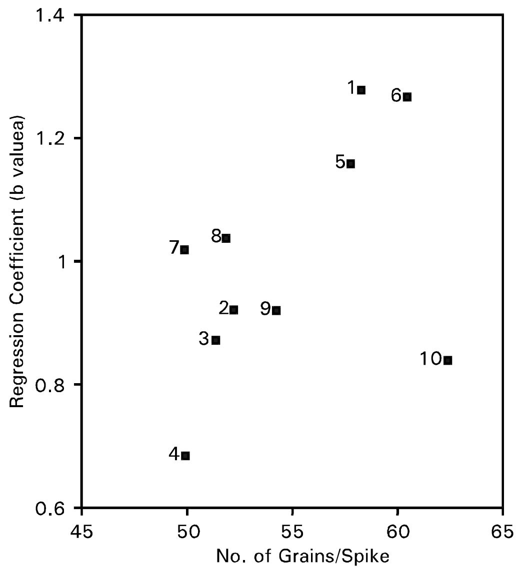

Fig. 1: Relationship of genotype adaptation (regression coefficient) and number of grains/spike

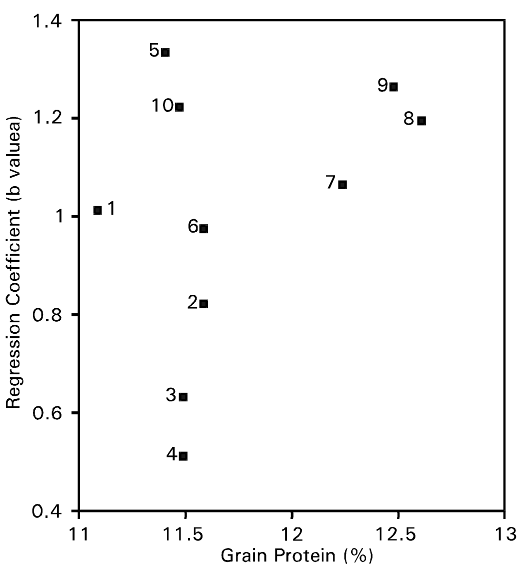

Fig. 2: Relationship of genotype adaptation (regression coefficient) and grain protein percentage

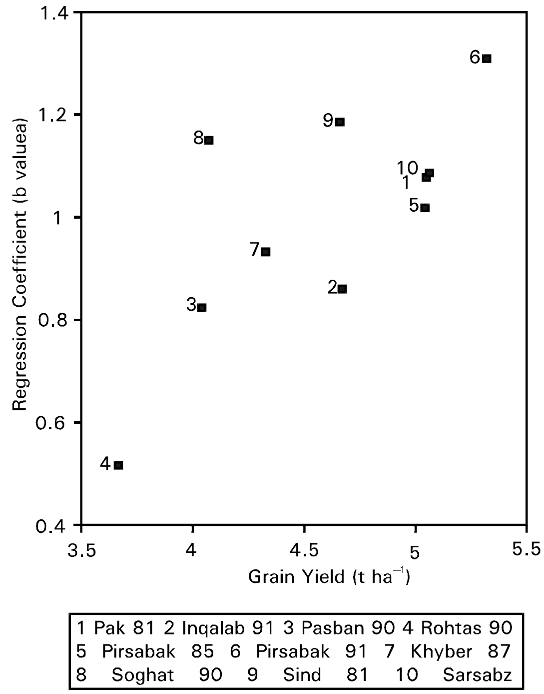

Fig. 3: Relationship of genotype adaptation (regression coefficient) and grain yield

The variation in the relationship of number of grains per spike, grain protein percentage and grain yield at different location (Table 3) reflected significant environmental effect on the performance of the genotypes. Significantly positive association of grains per spike with grain yield at eight out of nine locations indicates that grain yield can be increased by increasing number of grains per spike under most of the environments. Camargo (1987), Li (1989) and Mikheev (1992) also observed similar results.

Significantly negative ($P<0.05$) association between grains per spike and grain protein percentage at one location and non-significantly negative at six out of nine locations (Table 3) shows that increase in number of grains per spike may decrease grain protein percentage under certain environments. Mahmood and Shahid (1993) and Wells (1984) have reported similar results. As number of grains per spike contribute positively to grain yield therefore, efforts to increase to yield on the basis of number of grains per spike, 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 and non-significantly negative at six locations. In previous research, Campana and Semp (1984), Levy and Feldman (1989) and Millet *et al.* (1988) also recorded 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 number of grains per spike should not be exercised as a routine procedure as it may reduce grain protein percentage. However, non-significant relationship of grain protein percentage with number of grains per spike and grain yield at certain locations is an encouraging fact. This reality and the selection of plants with increase source potential 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 cultivars. In this context, It would be desirable to explore the effects of agro-ecological factors such as temperature, precipitation, soil fertility and their interactions on the development of these characters. Such information would help build understanding regarding the nature of their associations and its exploitation in breeding programmes.

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