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Relationship among Coleoptile Length, Plant Height and Tillering Capacity for Developing Improved Wheat Varieties

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ABSTRACT

Semi-dwarf wheat varieties developed after green revolution are highly responsive to management and have potential to produce high yield. However, this potential is not achieved in fields, because of poor seedling vigour. Coleoptile length plays an important role in seedling vigour but it was reported as positively associated with plant height in different sets of genotypes. This positive correlation of coleoptile length with plant height makes the simultaneous selection for long coleoptile and reduced plant height impossible. A panel of 300 genotypes including several Pakistani and CIMMYT germplasm accessions were investigated for correlation, heritability and genetic advance for coleoptile length, plant height and tillering capacity. Although the genetic variation found in coleoptile length and plant height was highly significant ($P<0.01$), the coleoptile length was not related to variation in plant height ($r=-0.034^{NS}$). High estimates of heritability and genetic advance were found for coleoptile length and plant height (86 & 80% & 4.26 & 11.28, respectively). © 2011 Friends Science Publishers

Key Words: Coleoptile; Correlation; Genetic advance; Heritability; Wheat

INTRODUCTION

Grain production is a complex phenomenon, entailing several contributing factors. These factors influence grain production both directly and indirectly and the breeder is naturally interested in investigating the extent and type of association of such traits. Towards a clear understanding of the type of plant traits and their exploitation in a breeding program, correlation analysis has been found useful and conclusive to evolve better varieties. Phenotypic and genotypic correlations within varieties are valuable indicators of the degree to which various characters are associated with the economic productivity (Waitt & Levin, 1998).

Post green revolution wheat varieties are short stature and highly responsive to management and fertilizer inputs with greater potential to yield high grain produce as compared to the earlier long statured varieties (Kush, 2001). Unfortunately, this potential is not actualized in field conditions mostly, because of poor early vigour and low seedling establishment. Coleoptile length plays an important role in early vigor, seedling establishment and hence improves wheat yield (Rebetzke *et al*. 1999). It is an outer covering that protects the first leaf of the developing wheat plant as it pushes its way toward the surface of the soil during germination. If the coleoptile is shorter than the sowing depth, the first leaf must push through the soil and emerge in a dark environment. The longer it takes the first leaf to reach the surface, the more vulnerable the seedling is to soil crusting and diseases. Thus coleoptile is essential for successful emergence and early plant vigor.

A close association between coleoptile length and mature plant height has been established in previous investigations (Allan *et al*. 1962; Allan, 1980). Most of the reports involved Norin-10 derived wheats and suggested that short coleoptile length and short plant height are inherited pleiotropically. However, short wheats with only minor reductions in coleoptile length have also been reported (Gale & Youssefian, 1985) and at least one report on the inheritance of the two traits has suggested that the association between coleoptile length and plant height is not completely positive (Allan 1980).

Rebetzke *et al*. (1999) analyzed a highly variable Germplasm material with respect to plant height and coleoptile length ($P<0.01$) and found no association in plant height with any change in coleoptile length of the selected groups. It therefore seems feasible to develop wheat varieties with long coleoptiles and short stature (Fick & Qualset, 1976). The shorter coleoptiles of semidwarf wheats do not adversely affect establishment when seedbed conditions are favorable, however, short coleoptiles can reduce yield through poor seedling establishment when conditions are less favorable (Donald & Puckridge, 1975) and may result in lower emergence (Hughes & Mitchel, 1987; Addae *et al*., 1991).

Productive tillers are an important part of the wheat plant and grain yield depends on plants per area, tillers per plant kernels per tiller, and weight per kernel. Therefore,

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tillering plays a significant role in plant productivity. In cereals, most tillering occurs from main axis of the plant (main stem tillers). A second source of tillers is coleoptiles tillers that arise from belowground from a node at the base of the coleoptile. Liang and Richards (1994) reported a positive association between coleoptile tillers and fast early vigour in wheat.

The present studies were conducted to investigate the genetic variability, pattern of variability and association among coleoptile length, plant height and tillering capacity in a large collection of wheat genotypes including several Pakistani and CIMMYT germplasm lines. Early seedling vigour, reduced height and more productive tillers play a pivotal role in drought tolerance and therefore, the information resulting from these studies would be useful for wheat breeders to evolve high yielding varieties for water stress conditions.

MATERIALS AND METHODS

The present research was conducted in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture Faisalabad. The experimental material comprised of 300 old and new varieties grown in different ecological regions of Pakistan as well as some lines collected from CIMMYT (data not shown). The genotypes were space planted in field according to randomized complete block design with three replications. An experimental unit consisted of one row of 5m length with inter-plant distance of 15 cm and distance between rows 30 cm. All cultural practices were performed during the cropping season according to the recommended package of crop production technology. At maturity, ten guarded plants from each row were selected randomly and data were recorded for plant height (cm) and number of tillers per plant. For the measurement of coleoptile length the genotypes were sown in sand blocks in randomized complete block design with three replications.

The data for all these attributes were subjected to analysis of variance following Steel *et al*. (1997). Genotypic correlations were worked out according to the method given by Kwon and Torrie (1964). Heritability in broad sense as a ratio of genotypic to phenotypic variance was calculated for each trait. The expected genetic advances for l0% selection intensity of plant height, number of tillers per plant and coleoptile length were estimated from the formula described by AIlard (1960).

RESULTS

The analysis of variance (Table I) showed that mean square values of coleoptile length, plant height and number of tillers per plant were highly significant at both levels of ($P<0.01$) and ($P<0.05$). The range of plant height in the germplasm was 62 to 134 cm with mean of 97.3 cm. The range of variation in coleoptile length was from 1 cm to 8.8 cm with mean of 4.75 cm. Productive tillers ranged from 3 to 37 with mean value of 13.1 (Fig. 1). Genotypic correlations for all possible combinations for traits under study are presented in Table II. Correlation of coleoptile length with plant height and number of tillers was negative but non-significant. Plant height showed positive and highly significant correlation with number of tillers per plant.

Result pertaining to various genetic parameters viz; Phenotypic and genotypic variations, broad sense heritability and genetic advance are presented in Table III. Analysis of variability of studied characters revealed that phenotypic coefficient of variance (PCV) values were higher than genotypic coefficient of variance (GCV) values reflecting that expression of these traits is highly influenced by the environment. The highest PCV and GCV values were observed for coleoptile length 59.62 and 55.22% respectively followed by number of tillers per plant as 27.74 and 23.99%, respectively. Plant height had coefficient of phenotypic variability 8.28% and genotypic variability 7.28%. GCV values only are not enough to determine the genetic variability this could be done with the help of heritability also. Heritability estimates were high for coleoptile length (86%), (80%) for plant height and (74%) for number of tillers per plant. The significant estimates of heritability in broad sense associated with all traits.

Heritability estimates must accompany with a high genetic advance to be reliable. Therefore, genetic advance was also computed. The results indicated that maximum genetic advance of (11.28) for plant height, (4.70) for number of tillers per plant and (4.26) for coleoptile length. High heritability and genetic advance for plant height, number of tillers per plant and coleoptile length indicate the presence of additive gene effects.

DISCUSSION

Earlier studies revealed that coleoptile length was positively correlated with plant height (Allan *et al*., 1962; Allan, 1980; Gale & Youssefian, 1985; Rebetzke *et al*., 1999). This positive correlation makes impossible to breed a wheat variety with long coleoptile and reduced plant height. Rebetzke *et al*. (1999) investigated that the genotypes harboring gibberellic acid (GA)-insensible plant height genes (*rht1* and *rht2*) had positive correlation of plant height and coleoptile length. Conversely the genotypes with GA-sensitive plant height genes have poor correlation of coleoptile length with plant height. Correlation between coleoptile length and plant height was non-significant. This shows that the majority of genotypes under study lacked *rht1* and *rht2* genes and could be exploited to breed long coleoptile and reduced plant height wheat varieties. Poor correlation of coleoptile length with plant height was reported by Awan *et al.* (2007). In line with previous studies (Awan *et al.*, 2007; Ajmal *et al.*, 2009), plant height showed a positive correlation with number of tillers per plant in the present case as well.

Table I: Mean squares for coleoptile length, plant height and number of tillers per plant in ANOVA

SOV	df	Coleoptile length	Plant height	No. of tillers/ plant
Replication	2	0.199^{NS}	12.6^{NS}	12.17^{NS}
Genotype	299	23.09**	168.8**	32.96**
Error	598	2.44	12.9	3.33

Table II: Correlation matrix among the morphological characters

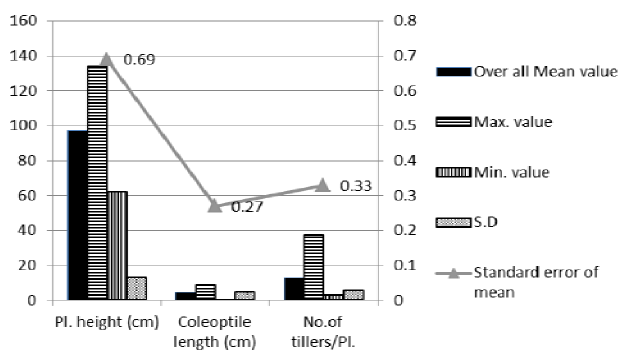
Characters	Coleoptile length	Plant height	No. of tillers/ plant
Coleoptile length	1.00	-0.034	-0.022
Pl. height	-0.034	1.00	0.132**
No. of tillers/Pl.	-0.022	0.132**	1.00

* = Significant (P ≤0.05); ** = highly significant (P ≤0.01)
Correlation values were calculated by using Minitab 13 software

Table III: Phenotypic coefficient of variation (PCV %), Genotypic coefficient of variation, Broad sense heritability and expected Genetic advance for three characters in 300 genotypes

Characters	Phenotypic variation (PCV)	Genotypic variation (GCV)	Heritability (h^2_{BS})%	Genetic advance (G.A)
Pl. height	8.28	7.41	80	11.28
Coleoptile length	59.62	55.22	86	4.26
No.of tillers/Pl.	27.74	23.99	74	4.70

Fig. 1: Minimum, maximum, over all means and Standard deviation of wheat germplasm



Genotypic and phenotypic coefficients of variation provided a glance of available variation in breeding material for all traits. The study showed little differences in genotypic and phenotypic coefficients of variability, which indicated that large amount of variation was contributed by genetic components and less by environmental influence (Jagashoran & Mishra, 2005).

Estimates of PCV and GCV were high for number of tillers per plant, which is similar to previous reports (Kashif & Khaliq, 2004; Ali *et al.,* 2008; Kumar *et al.,* 2009) and Plant height had coefficient of phenotypic variability 8.28% and genotypic variability 7.28% as reported by Din *et al.* (2010).

Heritability estimates were high (86%) for coleoptiles length, (80%) for plant height and (74%) for number of tillers per plant. The results are in accordance with the finding of Ali *et al.* (2008), Ibrahim and Hussein (2006), Kashif and Khaliq (2004), Sachan and Singh (2003), Jedynski (2001), Rebetzke *et al.* (1999), Pal and Garg (1992) and Mahmood and Shahid (1993). High value of broad sense heritability for plant height, number of tillers per plant and coleoptile length showed that these characters were least influenced by environment so there is a great chance of improvement through selection. High genetic advance was obtained for plant height it verifies the work of Bhutta (2006), Ali *et al.* (2008) and Kashif and Khaliq (2004).

Sharma and Garg (2002), Dwivedi *et al.* (2002) and Ali *et al.* (2002) reported that high heritability accompanied with high genetic advance in case of plant height, number of productive tillers per plant and coleoptile length are most likely the heritability is due to additive gene effects and selection may be effective in early generations for these traits. Similar results were obtained in our study.

In conclusion, germplasm analysis and evaluation in the present study showed that increase in coleoptile length is independent of decrease in plant height or increase in tillering capacity, which supports the idea that development of wheat varieties with reduced plant height and longer coleoptiles is possible in spring bread wheat. Furthermore, the results also showed that early generation selection for longer coleoptile may be effective for breeding improved varieties.

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