

Coleoptile length studies in semi-dwarf wheat (*Triticum aestivum* L.) with different dwarfing genes

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ABSTRACT

Eleven genotypes (seven varieties and four lines) were studied for coleoptile length. The genotypes having *Rht₁*, *Rht₂*, *Rht₁Rht₂*, *Rht8Rht9* and *rht* were compared for their coleoptile length under controlled environmental conditions. The results suggested that the traditional tall variety C-591 (*rht*) had longer coleoptiles compared to the remaining varieties and genotypes. The genotypes which had the next longest coleoptile length were Chinese Spring (*rht*) and Rht8-01 (*Rht8*). The varieties Mara (*Rht8Rht9*), Sarsabz (*Rht₁*) and Soghat-90 (*Rht₂*) were not significantly different for their coleoptile length. The line Rht8-02, which carries *Rht8* dwarfing genes, was not significantly different to the Yecora (*Rht₁Rht₂*), a double dwarf variety. These results suggest that the dwarfing genes probably do not affect the coleoptile length. The genetic background may affect the coleoptile length of individual varieties.

INTRODUCTION

Lack of moisture near the soil surface commonly delays sowing, reducing grain yields of the wheat (*Triticum aestivum* L.) crop in Pakistan. Deep sowing would allow growers to make use of soil moisture lying below the dryer topsoil, but the short coleoptiles of semi-dwarf wheats reduce emergence when sowing at depths greater than 5 cm. Selection of longer, thicker coleoptiles would help in improving emergence in hard or crusted soils, or when deep sowing, yet little is known of genetic control of coleoptile size in wheat. Rebetzke et al. (2004) reported that coleoptile length for progenies derived from *Rht8*, *Rht9*, and *Rht12* dwarfing gene donors were generally shorter (7 to 13%) but were still an average 47% longer than coleoptiles of *Rht-B1b* and *Rht-D1b* controls. Rebetzke et al. (2001) reported that differences in coleoptile length among varieties were substantially larger than for effects associated with either grain size or seed production source. Standard height (*rht*) and gibberellic acid (GA)-sensitive Rht8/9 semi-dwarf wheat varieties produced coleoptiles that were between 25 to 40% longer than GA-insensitive *Rht-B1b* and *Rht-D1b* semi-dwarf varieties. Furthermore, increasing mean soil temperature from 11 to 19 °C reduced coleoptile length by 20% in *rht* and *Rht8/9* wheats and by as much as 50% in *Rht-B1b* and *Rht-D1b* semi-dwarfs. The selection for increased coleoptile length can be made readily in a wheat-breeding program which includes GA-sensitive parents. Bai et al. (2004) reported that coleoptile length varied among accessions from 4.4 to 11.4cm. Frequency

distributions for 192-bp (with *Rht8*) and non-192-bp (without *Rht8*) genotypes showed no advantage of the 192-bp allele to coleoptile elongation. None of the 192-bp genotypes from the Great Plains showed greater coleoptile length than 'TAM 107', a hard red winter cultivar without *Rht8*, often chosen over contemporary cultivars for its greater emergence capacity with deeper seed placement. Since coleoptile elongation may be controlled by several quantitative trait loci, identifying only the presence of 192-bp allele of Xgwm 261 may be misleading if the primary motivation for its deployment is to increase coleoptile length in a semi-dwarf plant type. Rebetzke et al. (2007) demonstrated the importance of good seedling emergence in achieving high wheat yields, and the potential use of alternative dwarfing genes such as *Rht8* in development of long coleoptile, reduced height wheat suitable for deep sowing.

The Norin-10 dwarfing genes, *Rht-B1b* (*Rht1*) and *Rht-D1b* (*Rht2*) are commonly used to reduce plant height and increase grain yield in wheat breeding programs (Gale and Youssefian, 1985). These dwarfing genes lower sensitivity of vegetative tissue to endogenous gibberellin to reduce cell and subsequent stem elongation. This reduction in cell elongation capacity reportedly results in a concomitant reduction in coleoptile length and early vigor (leaf area), thereby affecting seedling establishment and growth. Rebetzke et al. (2001) reported that the negative genetic effect of the *Rht-B1b* dwarfing gene on early growth of wheat confirms phenotypic evidence of a pleiotropic effect of *Rht-B1b* on establishment and early vigor. Genetic increases in coleoptile length and early leaf area development are likely to be limited in wheat populations containing the *Rht-B1b* dwarfing gene. The aim of this study was to determine the effects of dwarfing genes on coleoptile length and other agronomic characteristics.

MATERIALS AND METHODS

Eleven genotypes (seven varieties and four advanced lines) were studied and evaluated to check the effects of height genes on coleoptile length. The twenty seeds of each of the eleven genotypes were stained with 2% sodium hypochlorite for 2 minutes then washed in distilled water three times prior to grow. These seeds

were then sown on filter paper in petri dishes. The experiment was conducted according to Hakizimana et al. (2000) and Bai et al. (2004) with some modifications. The studies were conducted in a growth chamber with three replicates, each with 20 grains. The temperature was maintained at 15 °C and humidity at 60% for six days. Water was applied intermittently as required. The germination rates of lines were good. The coleoptile length of each genotype was measured in centimeters (cm). The plants were grown to maturity for agronomic studies under field conditions.

RESULTS AND DISCUSSION

COLEOPTILE LENGTH

The traditional tall variety C-591 had the longest coleoptile length compared to the remaining varieties and genotypes (Table 1). The remaining genotypes which had longest coleoptile lengths were Chinese Spring and Rht8-01, which did not differ significantly.

The varieties Mara (*Rht8/9*), Sarsabz (*Rht₁*) and Soghat (*Rht₂*) were not significantly different. The line Rht8-2 (*Rht8*) was not significantly different to the Yecora (*Rht₁Rht₂*), a double dwarf variety. Kiran-95 variety (*Rht₁*) was not significantly different from the Yecora variety. These results suggest that the dwarfing genes do not affect the coleoptile length; however, the genetic background may affect the coleoptile length of individual varieties. Rebetzke et al. (2001 and 2004) reported that the coleoptile length of progenies derived from *Rht8*, *Rht9*, *Rht12* and *rht* (tall) had comparatively longer coleoptile lengths than the progenies with GA-insensitive (*Rht-B1b* and *Rht-D1b*). Rebetzke et al. (2007) reported that wheat containing the *Rht-B1b* or *Rht-D1b* dwarfing genes produced significantly shorter coleoptiles than both *Rht8* and tall (*rht*) wheat. However, other workers reported that the genotypes with *Rht8* (192bp) and without *Rht8* had no significant differences (Bai et al. 2004).

Table 1. Coleoptile length and agronomic performance of wheat varieties with different dwarfing genes

Lines/Variety	<i>Rht</i> genes	Coleoptile length (cm)	Plant height (cm)	Spike length (cm)	No.of grains/spike	Spike grain yield (g)
Mara	<i>Rht8 and Rht9</i>	3.72 d	84.3 e	9.15 f	52.15 c	1.03 g
<i>Rht8-2</i>	<i>Rht8</i>	3.17 f	68.6 h	11.3 c	67.55 b	2.10 c
Anmol-91	<i>Rht2</i>	2.64 g	82.4 f	12.25 b	66.9 b	2.52 b
Chinese Spring	<i>rht rht</i>	4.77 b	106.5 b	8.45 h	35.30 f	0.81 h
Rht8-1	<i>Rht8</i>	4.87 b	75.1 g	9.30 f	66.25 b	2.45 b
6-06	<i>rht rht</i>	4.28 c	106.2 b	13.47 a	70.65 a	2.66 a
Kiran-95	<i>Rht1</i>	3.44 e	88.5 d	12.05 b	52.3 c	1.75 de
C-591	<i>rht rht</i>	5.12 a	114.5 a	8.78 g	40.5 e	1.20 g
Soghat-90	<i>Rht2</i>	3.62 d	91.1 c	10.90 d	52.8 c	1.57 f
Sarsabz	<i>Rht1</i>	3.64 d	87.3 d	11.03 d	54.85 c	1.85 d
Yecora	<i>Rht1 Rht2</i>	3.30 ef	59.1 i	10.35 e	49.1 d	1.66 ef

PLANT HEIGHT

The tall variety C-591 was the tallest (plant height) of all the varieties or lines (Table 1). Chinese Spring and another line 6-06, were also tall, but not significantly different. Sarsabz and Kiran-95 both carry *Rht₁* gene and were not significantly different. The varieties carrying *Rht8* viz. Rht8-2, Rht8-1 and Mara were significantly different. Yecora (*Rht₁* and *Rht₂*) had, significantly, the shortest plant height.

SPIKE LENGTH

In this comparison the tall line 6-06 had the longest spike and was significantly different to the remaining varieties and genotypes. The other varieties/genotypes which had long spikes were Kiran-95, and Anmol-91.

Mara and Rht8-1 both carry *Rht8* gene and were not significantly different. Sarsabz and Soghat-90 varieties had no significant differences.

NUMBER OF GRAINS PER SPIKE

The tall line 6-06 had the highest number of grains per spike than other lines and varieties. The variety Anmol-91 with *Rht₂* was not significantly different from Rht8-1 and Rht8-02 lines, both carrying *Rht8*. Maras, an Italian variety carrying *Rht8* and *Rht9*, was not significantly different from Sarsabz (*Rht₁*), Kiran-95 (*Rht₁*) and Soghat-90 (*Rht₂*).

MAIN SPIKE GRAIN YIELD

In this comparison line 6-06 had the highest grain yield from the main spike. The line Rht8-1 (*Rht8*) was not

significantly different from Anmol-91 variety (*Rht₂*). Kiran-95 was not significantly different from Yecora variety which carries both dwarfing genes (*Rht₁* and *Rht₂*). Soghat-90 variety was not significantly different from Yecora a double dwarf variety.

CONCLUSION

The results suggest that the dwarfing genes do not affect the coleoptile length. The genetic background may affect the coleoptile length of individual varieties.

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