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Distribution of dwarfing genes *Rht-B1b* and *Rht-D1b* in Indian wheat (*Triticum aestivum*) cultivars detected by functional markers

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ABSTRACT

The present study was conducted to determine the frequency of allelic variations for *Rht-B1b* and *Rht-D1b* in wheat (*Triticum aestivum* L.) cultivars grown in different agro-climatic zones of India and to investigate the agronomic performance (plant height, average yield, no. of spikelets/spike, no. of seeds/spike and 1 000 grain weight) with allelic variants of *Rht* genes. One hundred Indian wheat varieties released during the period of 1968-2006 were screened with PCR based STS marker for *Rht-B1b* and *Rht-D1b*. *Rht-B1b* allele predominates in the North Western Plains Zone of India with a frequency of 25%. *Rht-D1b* was found in the 15% of the cultivars which are mainly cultivated in Central Zone. None of the dwarfing allele had been found in the cultivars of Northern Hills Zone. Cultivars having *Rht-B1b* allele had significantly highest average yield than wheat genotypes without any of these dwarfing allele. *Rht-B1b*+*Rht-D1b* allele was found in 7% of the cultivars out of the selected ones dominating North Western Plains Zone.

Key words: Functional marker, Reduced height, *Rht-B1b, Rht-D1b,* Wheat

India ranks second in wheat production across the world with a 93.9 million tonnes production in year 2011-2012 (Anonymous 2011). India is divided into six different agroclimatic zones and bread wheat (*Triticum aestivum* L.) accounts for approximately 95% of the wheat grown, while 4% is durum wheat (*T. durum*) and 1% is dicoccum (*T. dicoccum*) wheat (Gupta 2004). In developing countries, more than 95% of commercial wheat cultivars are semi-dwarf lines (Heisey *et al.* 1999), which shows the importance of utilization and research of dwarfing genes. Wheat grain yields have increased following the widespread incorporation of reduced height (*Rht*) alleles in wheat breeding programmes to produce semi-dwarf wheats (Chapman *et al.* 2007). Till date, 21 *Rht* genes have been identified in wheat having significant effect on reducing plant height (McIntosh *et al.* 1995). The height-reducing *Rht-B1b* and *Rht-D1b* genes derived from Norin 10 are located on homoeologous chromosomes 4BS and 4DS respectively and encodes protein involved in gibberellin (GA) signal transduction (Peng *et al.* 1999). By conferring insensitivity to GA, these genes have pleiotropic effects on plant growth, causing reductions in coleoptile length and seedling leaf area (Whan 1976, Rebetzke *et al.* 2001). Many semi-dwarf and dwarf wheat varieties are grown in different agro-climatic zones of India, but little information is available about the distribution of *Rht* genes responsible for dwarfing cultivars and their influence on overall cultivation of wheat in different agro-climatic zones of India. The aim of the present study was to investigate the distribution and validation of *Rht-B1b* and *Rht-D1b*, in wheat cultivars grown in different wheat zones of India using STS markers and to find any correlation of the dwarfing gene with the agronomic traits. The information derived will be valuable for future wheat breeding programmes.

MATERIALS AND METHODS

A total of 100 Indian wheat cultivars, released during the period of 1968-2006 from different wheat cultivating agro-climatic zones of India, viz. North-Western Plains Zone (NWPZ), North-Eastern Plains Zone (NEPZ), Peninsular Zone (PZ), Central Zone (CZ) and Northern Hills Zone (NHZ) were screened with two diagnostic markers for *Rht-B1b* and *Rht-D1b*. Field data for agronomic characters was taken in crop season. Trials were conducted for three consecutive years from 2004-2007 at Directorate of Wheat Research, Karnal and data for agronomic traits like plant height, number of spikelets/spike, number of seeds/spike, 1 000 grain weight (TGW) and average yield were collected as per Protection of Plant Varieties and Farmers' Rights Act

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Genomic DNA was extracted from one-week-old seedlings using CTAB method (Doyle and Doyle 1990). The gene-specific primers for the detection of *Rht-B1b* and *Rht-D1b* were got synthesized from M/S Bangalore genei (www.bangaloregenei.com) based on the report of Ellis *et al.* (2002) with minor modifications done by Zhang *et al.* (2006).

T-test was used for comparing plant height, 1 000 grain weight, number of spikelets/spike, number of seeds/spike and average yield, in the cultivars possessing *Rht-B1b* and *Rht-D1b* and those having *Rht-B1a* and *Rht-D1a*.

RESULTS AND DISCUSSION

A total of 100 Indian wheat varieties from five wheat growing zones including three varieties grown in all zones were screened for their allelic variation of *Rht-B1b* and *Rht-D1b* dwarfing gene (Table 1). The homoeologous genes *Rht-B1 and Rht-D1* were molecularly characterized and both mutations involve single base-pair changes leading to a TAG stop codon shortly after the start of translation (Peng *et al.* 1999). In NWPZ, the major wheat growing zone of India, 37% genotypes had *Rht-B1b* allele and 16% had *Rht-D1b* allele (Fig 1). Out of 12 wheat varieties selected from NHZ, none of the semi-dwarfing alleles had been observed in any of the genotype.

The plant height was grouped into 5 categories: very short (< 60 cm), short (60.1-75 cm), medium (75.1-90 cm), long (90.1-115 cm) and very long (>115 cm). Wheat varieties either with *Rht-B1b, Rht-D1b* or combination of both were significantly shorter in height than non-dwarf cultivars (Fig 2).

Out of 100 wheat varieties, only 7% of the cultivars carried both the semi-dwarfing allele (*Rht-B1b and Rht-D1b)*, whereas 53% did not harbour any of the dwarfing allele. The amplification product size corresponds to the reported size (Ellis *et al.* 2002). Twenty three varieties carrying the *Rht-B1b* mutation showed an amplification product of the expected size (237 bp) while complementary results came out with *Rht-B1a* tall allele, as expected. Fifteen varieties amplified a 254 bp PCR fragment indicating the presence of *Rht-D1b* allele while tall allele *Rht-D1a* gave complementary results having an amplified fragment of 264 bp. Wheat varieties having either of the dwarfing allele or combination of both the allele were significantly shorter than those genotypes which are devoid of it (Table 2). Our findings on the variation in the final plant height in varieties having the same *Rht* gene suggest that some additional genes influence the expression of height in wheat. In addition to *Rht* genes which have major effect on plant height, there are numerous studies showing polygenic control of this trait and involvement of other chromosomes (Worland 1996, Cadalen *et al.* 1998). Some varieties which were phenotypically tall showed one of the dwarfing allele (Table 1) limiting the applied detection method. The significant cause behind this phenomenon might be unspecific binding of primers in the same locus, as this method is SNP based, resulted the appearance of same amplification product even in the absence of tagged sequence. There are however reports where these primers fail to amplify in all cases expected or that do not show linkage with the phenotype (Prabhu *et al.* 2003). High diversity among the parents could be one of the reason for imprecision of the applied method.

A number of agronomic traits (plant height, average yield, no. of spikelets/spike, no. of seeds/spike and 1 000 grain weight) were also studied. The effect of dwarfing genes on the agronomic characters of wheat has been reported previously (Li *et al.* 2006) and very crucial for proper

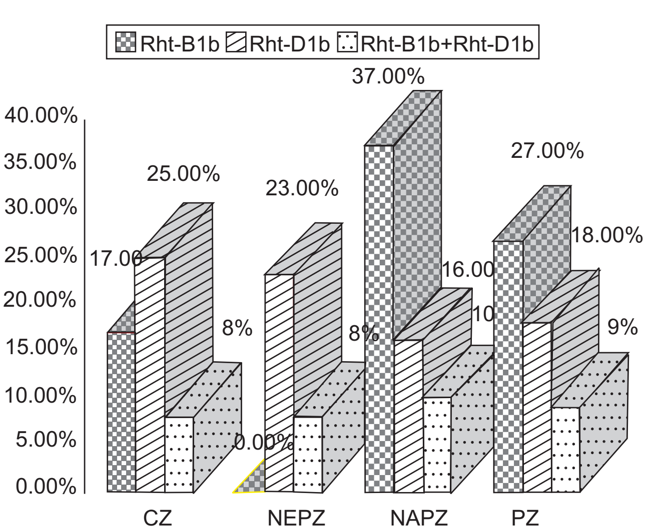

Fig 1 Frequency of *Rht-B1b, Rht-D1b* and *Rht-B1b+Rht-D1b* alleles in wheat cultivars grown in different agro-climatic zones of India.

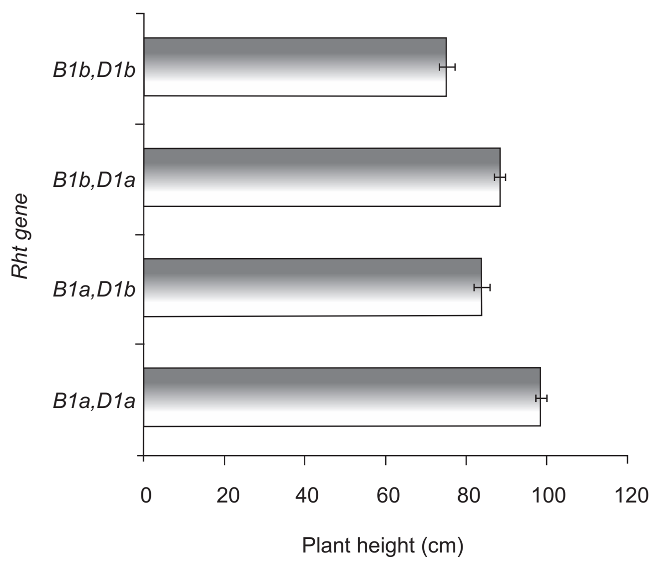

Fig 2 Average plant height related to the *Rht* allele in Indian wheat varieties.

Table 1 List of Indian wheats screened for *Rht-B1b* and *Rht-D1b*

Cultivar	Year of release	Zone	Plant height (cm)	*Rht* genotype				Parentage
				B1a	B1b	D1a	D1b	
AKW 1071	1995	CZ	85 (80-94)	+	-	+	-	VEE'S'/3/FLN/ACC//ANA
BW 11 (PURBALI)	1987	NEPZ	87 (85-92)	-	+	+	-	KVZ/TI 71//TZTO
C 306	1969	NEPZ	111 (105-129)	+	-	+	-	REGENT19473*CHZ//*2C591/3/P 19/C 281
Chotti lerma	1969	NWPZ	87 (85-90)	-	+	+	-	LR 64 'S'//HUAR
CPAN-1676	1984	NWPZ	90 (85-96)	+	-	-	+	BON//CNO/S 64/3/KAL/ BB
DBW 14	2002	NEPZ	77 (72-82)	-	+	-	+	RAJ 3765/PBW 343
DBW 16	2006	NEPZ	92 (90-95)	+	-	+	-	RAJ 3765/WR 484// HUW 468
DL 153-2(Kundan)	1985	NWPZ	96 (87-96)	+	-	+	-	TANORI 71/ NP 890
DL 788-2 (VIDISHA)	1997	CZ	83 (77-89.2)	-	+	-	+	K 7537/HD 2160 MUT //HD 2278/DL 896-2 (LR24/SR24)
GW 120	1985	NWPZ	104 (100-110)	-	+	+	-	INIA 66/CNO//INIAI66/BB/3/Y 50E/3*KAL
GW 173	1994	CZ	83 (80-88)	+	-	-	+	TW 275 /7/7/10/ LOK-1
GW 190	1994	CZ	94 (85-98)	-	+	+	-	VEE/3/BB'S'/SKA//ARJUN
GW 322	2002	PZ	93 (55-100)	+	-	+	-	PBW 173/GW 196
HD 1949(Moti)	1971	NWPZ	63 (60-67)	-	+	-	+	YT 54/N 10B// NP 852
HD 1982 (JANAK)	1975	NEPZ	79 (75-84)	+	-	-	+	E 5557/HD 845
HD 2009(Arjun)	1975	NWPZ	85 (80-88)	-	+	+	-	LR 64A / NAI 60
HD 2189	1980	PZ	96 (90-100)	-	+	+	-	HD 1963 / HD 1931
HD 2285 (GOBIND)	1984	NWPZ	87 (83-93)	-	+	+	-	HD 1918/ HD 1592/3/HD 1962//E 4870/K 65/4/ HD 2160/5/HD 2180
HD 2329	1985	NWPZ	81 (73-96)	+	-	+	-	HD 1962 /E 4870/3/K65/3/HD 1553/UP 262
HD 2428	1989	NPZ	78 (72-81)	-	+	-	+	HD 1949 /HD 2160
HD 2687 (SHRESTH)	1999	NWPZ	92 (86-98)	+	-	+	-	SPAN 2009 / HD 2329
HD 2733 (VMS)	2001	NEPZ	88 (87-90)	+	-	-	+	ATTILA/3/TUI/CARC//CHEN/CHTO/4/ ATTILA
HD 2781 (ADITYA)	2002	PZ	99 (93-104)	+	-	+	-	BOW /C 306 //C 591/ HW 2004
HD 2833 (TRIPTI)	2006	PZ	90 (80-95)	-	+	+	-	PBW 226 / HW 1042 // HD 2285
HD 2864 (URJA)	2004	CZ	80 (77-81)	+	-	+	-	DL 509-2/ DL 377-8
HD-1941(Heera)	1970	NWPZ	71(65-78)	-	+	-	+	YT 54/NOR 10 B//SONORA 64
HD-1981(Pratap)	1978	NWPZ	79 (75-82)	-	+	-	+	E5557 /HD 845
HI 1500 (AMRITA)	2003	CZ	121 (119-132)	+	-	+	-	HW 2002*2/STREMPALLI/PNC 5
HI 977	1988	PZ	94 (86-101)	+	-	+	-	GLL/AUST 61.157//CNO NO 66/3/Y50E/KAL
HS 1097-17 (Girija)	1978	NHZ	105 (91-110)	+	-	+	-	CAJAMME 60/E 4717
HS 207	1989	NHZ	94 (88-100)	+	-	+	-	KAVKAZ /BUHO//KAL/BB
HS 240	1989	NHZ	92 (86-97)	+	-	+	-	AU /KAL/BB/3/WOP/PAVON
HS 277	1992	NHZ	92 (90-95)	+	-	+	-	KAVKAZ/CIGUENA
HS 295	1992	NHZ	91 (80-99)	+	-	+	-	CQT/AZ//IA 555/ALDML'S'/NAFN/4/PJN'S'/ PEL 1276.69
HS 365	1998	NHZ	94 (91-101)	+	-	+	-	HS 207/SONALIKA
HS 375 (HIMGIRI)	2002	NHZ	105 (99-111)	+	-	+	-	BB/G 11/CJ 71/3/TAEST//KAL/BB
HS 420 (SHIVALIK)	2002	NHZ	101 (99-103)	+	-	+	-	KAJ 3302//CMH 73A-497/3*CNO 79
HUW 234	1986	NEPZ	96 (90-101)	+	-	+	-	HUW 12*2/SPAN 1666//HUW 12
HUW 468	1999	NEPZ	108 (103-114)	+	-	+	-	CPAN 1962 / TONI // LIRA'S' / PRL'S'
HUW 510	2002	PZ	90 (86-94)	+	-	-	+	HD 2278 / HUW 234 // DL 230-16
HW 2004 (AMAR)	1997	CZ	116 (104-122)	+	-	+	-	C 306*7//TR 380-14 #7 /3 AG 14
HW 657	1980	PZ	94 (91-104)	+	-	+	-	TIMGALEN */ K65
K 7903 (HALNA)	2002	NWPZ	79 (78-85)	+	-	-	+	HD 1982/K 816
K 8027	1989	NEPZ	104 (100-110)	+	-	+	-	HD 1969/K 852//K 852
K 9465 (GOMTI)	1998	NEPZ	114 (110-123)	+	-	+	-	B 1153/CB 85=HD 2402/CPAN 1830// VEES'
K 9644 (ATAL)	2000	PZ	107 (102-115)	+	-	+	-	HD 2402 /K 8305

Contd.

Table 1 *Continued*

Cultivar	Year of release	Zone	Plant height (cm)	*Rht* genotype				Parentage
				B1a	B1b	D1a	D1b	
K-68	1968	NWPZ	119 (107-120)	+	-	+	-	NP 773/C 13
Kalyan Sona	1969	NWPZ	89 (87-92)	-	+	+	-	FN//K 58/NTH.// N 10 B/4/GB 55
Kharchiya 65	1970	All Zone	118 (111-130)	+	-	+	-	KHARCHIA LOCAL/EG 953
KRL 1-4	1990	All Zone	89 (84-91)	-	+	+	-	KHARCHIA 65/ WL711
KRL 19	2000	All Zone	85 (82-90)	+	-	+	-	PBW 255/ KRL 1-4
KSML 3	1980	NWPZ	98 (94-111)	+	-	+	-	ML 253 RON-CHA*KAL-NOR 67 ML 265 (CNO-SON-KL.REND)*KAL2ML 277 GTO-KAL*BB CNO
Lal Bahadur	1971	NWPZ	62 (72-85)	+	-	-	+	S 54723*RS 31-1-ML-293 BB*KAL2ML 319 CNO-KAL*CD1(KAL-INIA*INIA-BB) ML328 BB-KAL2 ML 408 RON-CHA*KAL-NOR67 ML 414 TOB-INIA*KAL
Lerma Rajo	1965	CZ	93 (84-105)	+	-	+	-	Y50/N 10B//L 52/3/2*LR
LOK-1	1982	CZ	97 (96-105)	+	-	-	+	S308 / S331
MACS 2496	1991	PZ	89 (86-93)	-	+	-	+	SELECTION FROM SERI'S'
MLKS 11	1982	NWPZ	90 (87-101)	-	+	+	-	IWP 19 E 6254*KS2 IWP 72 E 6056*KS2 IWP 92 S 210*KS3WP 98 (NP 875-E 4849-NP 830)*KS2 IWP 123 (NP 875-E 4849-NP 830)*KS2 IWP 106 NORTENO 67*KS3 IWP 109 V 17-LR 64A*KS3 IWP 116 NP 852-E 4871*KS3 IWP 114 HD 1981*KS3
MP 4010	2003	CZ	87 (78-96)	+	-	-	+	ANGOSTURA 88
NI 5439	1973	PZ	106 (98-100)	+	-	+	-	REMP 80/3*NP 710
NW 1014	1998	NEPZ	102 (98-110)	+	-	+	-	HAHN'S'
NW 2036	2002	NEPZ	91 (86-94)	+	-	+	-	BOW/CROW/BUC/PVN
PBW 12	1984	NWPZ	93 (88-97)	+	-	-	+	CNO-GALLO /WL 7II
PBW 120	1987	NWPZ	87 (85-95)	-	+	+	-	WG 377/HD 2160
PBW 138	1987	NWPZ	90 (85-100)	+	-	-	+	RAVI 43/HD 2177
PBW 154	1988	NWPZ	90 (86-94)	+	-	-	+	HD 2160/HD 2177
PBW 175	1989	NWPZ	105 (101-109)	+	-	+	-	HD 2160 /WG 1025
PBW 222	1990	NWPZ	68 (63-70)	+	-	-	+	NP 890 / HD 2160
PBW 226	1989	NWPZ	85.2 (78.4-92)	-	+	+	-	WG 138/JUSTIN// CHRIS/HD 1941
PBW 299	1993	NWPZ	92 (88-103)	+	-	+	-	BB/KAL//WL 711 /PBW 65
PBW 343	1996	NWPZ	90 (85-93)	-	+	+	-	ND/VG9144//KAL/ BB/3/YCO'S' /4/ VEE# 5'S'
PBW 373	1996	NWPZ	87 (82-93)	-	+	+	-	ND/VG9144 //KAL/ BB/3/YACO 'S' /4/VEE# 5'S'
PBW 396	2000	NWPZ	89 (81-96)	+	-	-	+	CNO 67 /MFD//MON 'S'/3/SERI
PBW 443	2000	NEPZ	91 (88-99)	+	-	+	-	PBW 304 / CPAN 1922
PBW 502	2004	NWPZ	87 (80-94)	-	+	+	-	W 485 / PBW 343 // RAJ 1482
PBW 54	1983	NWPZ	91 (89-97)	-	+	+	-	HD 2160 /WG 377
PBW 65	1987	NWPZ	101 (96-110)	-	+	+	-	USA 255/K 816/3/ WL 202
PDW 291	2005	NWPZ	86 (82-90)	+	-	+	-	BOOMER 21/MOJO 2
Raj 1482	1983	NWPZ	95 (92-102.4)	+	-	+	-	NAPO/TOB 'S'/8156/KAL/BB
Raj 1972	1986	NWPZ	89 (85-98)	+	-	+	-	HD2195/HD2160
Raj 2184	1985	NWPZ	92 (88-97)	+	-	+	-	UP 291/HD 2206
Raj 3077	1989	NWPZ	96 (83-104)	+	-	+	-	HD 2267/ RAJ 1482// RAJ 1802
Raj 3765	1996	NWPZ	90 (86-95)	-	+	+	-	HD 2402/VL639
Raj 4037	2003	CZ	91 (83-95)	+	-	+	-	DL 788-2/RAJ 3717
Raj 911	1975	CZ	75 (72-80)	-	+	-	-	V-O229(CIMMYT)
UP 1109	1987	NHZ	107 (96-115)	+	-	+	-	UP 262/UP 368
UP 2113	1985	NWPZ	110 (99-115)	+	-	+	-	UP 346/WG 377

Contd.

Table 1 *Concluded*

Cultivar	Year of release	Zone	Plant height (cm)	*Rht* genotype				Parentage
				B1a	B1b	D1a	D1b	
UP 2121	1984	NWPZ	88 (80-94)	-	+	+	-	UP 366/SAMAKA 68
UP 215	1975	PZ	99 (98-107)	+	-	+	-	TZPP*SON.64
UP 2338	1995	NWPZ	94 (88-101)	+	-	+	-	UP 368/VAL 421//UP 262
UP 2425	1999	NWPZ	92 (90-195)	+	-	+	-	HD 2320/UP 2263
UP 301	1970	NWPZ	70 (62-78)	+	-	-	+	L.R.*SON.64
UP 368	1978	NWPZ	78 (72-85)	-	+	-	+	LR 64*SON.64
VL 738	1997	NHZ	106 (102-115)	+	-	+	-	NS12.07 /LIRA'S' // VEE'S'
VL 804	2002	NHZ	102 (99-116)	+	-	+	-	CPAN 3018 / CPAN 3004 // PBW 65
VL 829	2003	NHZ	106 (105-109)	+	-	+	-	IBWSN 149/ CPAN 2099
WG 377	1975	NWPZ	95 (91-100)	+	-	+	-	(WG 143*USA 255)*PV 18
WH 157	1978	NWPZ	92 (85-99)	+	-	+	-	NP 876/S 308//CNO/8156
WH 416	1990	NWPZ	74 (67-85)	-	+	+	-	WH 147/UP 368
WH 542	1992	NWPZ	82 (78-93)	-	+	+	-	JUPATECO/BLUEJAY //URES
WL 711	1977	NWPZ	96 (94-102)	+	-	+	-	NP/TOB'S'/3/8156//KAL/BB

Table 2 Variation in agronomic characters with different *Rht* alleles in wheat cultivars of India

Allele	Plant height (cm)	No. of spikelets/ spike	No. of seeds/ spike	TGW	Average yield (tonnes/ha)
B1a, D1a	98.75 (±1.31)	19.74 (±0.30)	57.32 (±1.26)	38.53 (±0.55)	3.13 (±0.15)
B1a, D1b	83.12 (±2.44) **	18.35 (±0.36)	54.24 (±1.87)	39.30 (±0.83)	3.69 (±0.21) *
B1b, D1a	88.66 (±1.35) **	19.17 (±0.28) **	61.22 (±1.60)	37.61 (±0.46)	3.82 (±0.16) **
B1b, D1b	75.00 (±2.87) **	18.86 (±0.64)	56.57 (±2.23)	39.00 (±0.69)	3.05(±0.53)

** Significantat at 1%, * significant at 5%

utilization of the dwarfing genes in the improvement of the wheat yields.

In our study, mean value of number of seeds/spike were significantly higher in cultivars carrying the *Rht-B1b* allele (61.22) in comparison to cultivars carrying the *Rht-D1b* allele (54.24) but no significant variation was found between cultivars having any of the dwarfing gene with the tall allele (Table 2). Pinthus *et al*. (1983) also concluded that overall mean yield of *Rht-B1b* semi-dwarfing lines were significantly higher than that of *Rht-D1b* lines. Fanny A´lvaro *et al*. (2008) derived the result that from the introduction of *Rht-B1* dwarfing gene increased the number of grains/spikelet, but it did not have any effect on the number of spikelets on the main spike. In addition to this, this study concluded that the genotypes having *Rht-B1b* allele had significant difference in number of spikelet/spike with those genotypes giving none of the dwarfing allele. It was earlier reported that higher grain number in modern bread wheat varieties were mainly from increase in the number of grains/spike and per spikelet (Perry and D' Antuono 1989, Sayre *et al.* 1997).

No significant difference was observed in thousand grain weight of genotypes with or without having *Rht* allele. Pinthus *et al.* (1990) reported significantly negative effect of 1 000 grain weight on *Rht-B1b, Rht-D1b* and *Rht-B1c* genotypes. It is considered that increase in the number of grains/unit area have been the significant factor for the increase of genetic yields (Siddique *et al*. 1989, Shearman *et al.* 2005) but no positive correlation have been found between yield improvement and grain weight (Brancourt-Hulmel *et al.* 2003, Shearman *et al.* 2005). Li *et al.* (2006) reported that both the *Rht-B1b* and *Rht-D1b* semi-dwarfing genes had significantly positive effects on kernel number and grain weight/spike.

The *Rht-B1b* and *Rht-D1b* genes had significantly positive effect (P<0.01 or 0.05) on average yield compared with the tall allele but no significant difference was found between the genotypes having *Rht-B1b*+*Rht-D1b* and genotypes having tall allele (Table 2). Earlier, Villareal *et al*. (1992) have reported that the *Rht-B1b* line gave higher yield potential than the *Rht-D1b* lines (P<0.05). The difference in average yield of *Rht-B1b* (3.82 tonnes/ha) and *Rht-D1b* (3.69 tonnes/ha) was not significant in the present study. This result was similar to the findings of Li *et al.* (2006) and Gale *et al.* (1985). Various reports confirmed the superiority of the cultivars having the *Rht-B1b* or *Rht-D1b* alleles over *Rht-B1a* possessing cultivars in their yielding ability (Gale *et al*. 1985). Fischer *et al*. (1990) also studied the effect of major dwarfing genes on yield potential and found that *Rht-*

B1b+Rht-D1b dwarfs gave more yield over *Rht-B1b* and *Rht-D1b* lines. Thus, it can be concluded that different environment and background plays a significant role which causes variations in the studies conducted by researchers.

This study concluded that there is widespread occurrence of semi-dwarfing genes in Indian wheat varieties having significant advantage on the average yield compared to the varieties carrying tall allele which could be one of the justification for their implications in the future wheat breeding programs in India and elsewhere. The information drawn from this study on height reducing gene and its correlation with other agronomic traits could be used by researchers for better exploration of the desirable traits from this material. More efforts will be required to detect other identified and unidentified dwarfing genes in Indian wheats.

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