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IDENTIFICATION AND INHERITANCE OF A NEW DWARFING GENE IN PIGEONPEA

S. C. GUPTA, R. K. KAPOOR, T. P. RAO AND R. P. ARIYANAYAGAM

Legumes Program, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru 502324

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ABSTRACT

A spontaneous dwarf (D_{11}) mutant was identified in an advanced line ICPL 146. In order to study inheritance of the dwarfness in D_{11} and its allelic relationship to the D_1 dwarfing gene, D_{11} was crossed with three tall lines (ICPL 146, ICPL 85024, ICPL 85037) and a D_1 dwarf (ICPL 85059) in 1986. The segregation patterns in F_1, F_2, backcrosses to both the parents and F_3 progenies suggested that D_{11} dwarfness is governed by a single recessive gene in homozygous condition (t_5t_5). The genes in D_{11} and D_1 were found to be nonallelic.

Key words: *Cajanus cajan*, dwarf mutant, inheritance.

The excessive vegetative growth related to tallness of traditional pigeonpea [*Cajanus cajan* (L.) Millsp.] cultivars leads to reduced harvest index and hinders efficient crop management practices. Delayed plantings can result in reduced height [1]. However, Mohammed and Ariyanayagam [2] argued that the use of genetic dwarfs would be a more desirable approach to reduce plant height.

A bushy dwarf pigeonpea with brittle branches and condensed internodes was reported [3–5]. They found that the dwarfness was controlled by a single recessive gene. Twelve sources of dwarfism (D_0 to D_{11}) in pigeonpea are available at ICRISAT Center. Genetic studies of the D_0 indicated that the dwarfness was controlled by two nonallelic recessive genes t_1t_1 and t_2t_2 [6]. Jain [7] found that dwarfing in D_1 was controlled by a single recessive gene (t_4t_4). Inheritance of dwarfness D_6, PD_1 (D_7) and PBNA (D_8) indicated that the dwarf phenotype in each of the three lines was controlled by a single recessive gene in homozygous state [8]. They also reported that D_6 and PD_1 had similar alleles (t_3t_3) and PBNA had a different allele ($t_3^h t_3^h$) for dwarfness.

During 1986 rainy season a spontaneous dwarf mutant plant was identified at the ICRISAT Sub-Center, Hisar in an advanced short duration pigeonpea line ICPL 146. Its height at maturity was 35 cm as against the 130 cm of ICPL 146. This dwarf was designated as D_{11}. The present study was conducted to study the inheritance pattern of the dwarfing gene in D_{11} and its allelic relationship to the gene controlling dwarfness in the D_1 dwarf, an extensively used parent in the crossing program at ICRISAT.

MATERIALS AND METHODS

Two dwarf (D_1 and D_{11}) and three tall (ICPL 146, ICPL 85024 and ICPL 85037) pigeonpea lines were included in this study. Characteristics of these dwarf and tall parents are summarized in Table 1. The D_{11} dwarf was the shortest parent with a mean height of 39.5 cm and ICPL 85037 was the tallest with a mean height of 120 cm. The mean plant height of D_1 dwarf (ICPL 85059) and tall parent ICPL 85024 was about the same (Table 1), however, the branching pattern and the internode length in these two parents were significantly different. ICPL 85024 had on an average 7.2 primary branches per plant at mean internode length of 5.3 cm, while ICPL 85059 (D_1 dwarf) had on an average 12.8 primary branches per plant at mean internode length of 1.9 cm. The internodes in D_1 dwarf are condensed so that acute branches radiate from a narrow region about 10 to 15 cm above the ground level. The main branches are brittle.

Table 1. Characteristics of the parents used in the study on pigeonpea

Parent	Plant height (cm)	No. of primary branches	Internode length (cm)	Days to flowering
D_{11} dwarf	39.5 ± 1.7	5.8 ± 0.3	3.0 ± 0.1	61.8 ± 0.4
D_1 dwarf (ICPL 85059)	85.7 ± 1.4	12.8 ± 0.7	1.9 ± 0.1	64.1 ± 0.6
ICPL 146	106.4 ± 0.9	7.9 ± 0.4	7.2 ± 0.2	66.5 ± 0.4
ICPL 85024	85.6 ± 1.0	7.2 ± 0.3	5.3 ± 0.2	58.5 ± 0.5
ICPL 85037	120.0 ± 0.6	9.0 ± 0.4	8.7 ± 0.2	63.6 ± 0.4

Each of the two dwarf lines was crossed to all the three tall parents and also among themselves to study allelic relationship. The F_1s were grown during 1987 at Hisar to produce F_2 seed and to backcross with both the parents. The parents, F_1, F_2 and backcross to both the parents were grown during 1988 at Hisar. The parents, F_1, and the backcrosses were planted in one row and F_2 populations were grown in 20 row plots of 9 m length. The rows were spaced 60 cm apart with intra-row spacing of 15–20 cm. The number of dwarf and tall plants in each generation for each of the four crosses were recorded. In each of the three F_2 populations involving crosses between D_{11} dwarf and the three tall parents, 20–50 and 52–231 tall plants were selected randomly to study the segregation pattern in the F_3 generation. In the 1989 rainy season F_2-derived F_3 progenies were grown at Hisar, along with their respective parents, in 9 m long one row plots. The observation on segregation of tall and dwarf plants in each single plant progeny was recorded separately for each of the three crosses. The chi-square test was applied to test the significance of segregation ratios.

RESULTS AND DISCUSSION

INHERITANCE

The F_1 plants of all the three crosses involving D_{11} dwarf and the three tall parents resembled their tall parents, suggesting that D_{11} dwarf is inherited as a recessive trait. In the F_2 populations obtained by crossing D_{11} dwarf with tall parents, the observed segregation of tall and dwarf plants fitted the expected 3 tall : 1 dwarf ratio indicating that the D_{11} dwarf phenotype was controlled by a single recessive gene in homozygous state (Table 2). This was further confirmed by the phenotypic segregation patterns in the backcrosses (Table 2) and F_3 progenies (Table 3). The backcross of F_1 to tall parent produced only tall progenies. Segregation in the test cross (F_1 x D_{11} dwarf) progenies of all the three crosses showed a good fit to the expected ratio of 1 tall : 1 D_{11} dwarf (Table 2). As expected within each cross, all the F_3 progenies of D_{11} dwarf F_2 plants bred true for dwarfness. However, two-thirds of F_3 progenies of tall F_2 plants segregated for D_{11} dwarf and tall plants and the remaining one-third bred true for tallness (Table 3). Within each segregating progeny, good fit for 3 tall : 1 D_{11} dwarf was found. The data pooled over the segregating F_3 progenies in each of the three crosses (Table 4) also showed a good fit for the expected 3 tall : 1 D_{11} dwarf ratio. These observations confirmed that D_{11} dwarfness was governed by a single recessive gene which we designate as t_5t_5. The dwarf stature in pigeonpea has been reported to be controlled by a single recessive gene [3–5, 7–9].

Table 2. Phenotypic classification of F_2 and test cross progenies between D_{11} dwarf and three tall pigeonpea lines

Generation and cross	Number of plants					Ratio	χ^2	P
	total	observed		expected				
		tall	dwarf	tall	dwarf			
F_2 : D_{11} x ICPL 146	1211	909	302	908.25	302.7	3:1	0.003	0.90–0.95
BC : F_1 x D_{11}	21	11	10	10.50	10.5	1:1	0.047	0.80–0.90
F_2 : D_{11} x ICPL 85024	1257	952	305	942.75	314.2	3:1	0.362	0.50–0.60
BC : F_1 x D_{11}	23	13	10	11.50	11.5	1:1	0.391	0.50–0.60
F_2 : D_{11} x ICPL 85037	1661	1262	399	1245.75	415.2	3:1	0.848	0.30–0.40
BC : F_1 x D_{11}	19	10	9	9.50	9.5	1:1	0.052	0.80–0.90
Pooled : F_2	4129	3123	1006	3096.75	1032.2	3:1	0.889	0.30–0.40
F_1 x D_{11}	63	34	29	31.50	31.5	1:1	0.397	0.50–0.60

Table 3. Segregation in F_3 progenies grown from random tall F_2 plants of the crosses between D_{11} dwarf and three tall parents of pigeonpea

Cross	Number of F_3 progenies					Ratio tested	χ^2	P
	total	observed		expected				
		segregating	non-segregating (tall)	segregating	non-segregating (tall)			
D_{11} x ICPL 146	98	63	35	65.3	32.7	2:1	0.252	0.60–0.70
D_{11} x ICPL 85024	231	149	82	154.0	77.0	2:1	0.486	0.40–0.50
D_{11} x ICPL 85037	52	32	20	34.7	17.3	2:1	0.616	0.30–0.40
Pooled	381	244	137	254.0	127.0	2:1	1.180	0.20–0.30

ALLELIC RELATIONSHIP WITH D_1 DWARF

The allelic relationship of D_{11} and D_1 (ICPL 85059) dwarfs was studied in F_1, F_2 and backcrosses to both the dwarf parents. All the plants in F_1 between D_1 and D_{11} dwarfs were tall, indicating that they have separate genes controlling their dwarfness designated as t_4t_4 and t_5t_5, respectively. Out of 1482 plants studied in F_2, 830 were talls, 386 were of D_1 dwarf type and 266 were of D_{11} dwarf type (Table 5) fitting the expected segregation ratio of 9:3:4. Presence of both the dominant genes (T_4 - and T_5 -) resulted in tall plants. Plants having t_5t_5 in recessive homozygous form in the absence of t_4t_4 (T_4–t_5t_5) were of D_{11} dwarf types and the plants having t_4t_4 in recessive homozygous form ($t_4t_4T_5$–and $t_4t_4t_5t_5$) were of D_1 dwarf tyeps. In double homozygous recessive plants ($t_4t_4t_5t_5$), t_4t_4 masked the effect of t_5t_5 resulting in D_1 dwarfs. As expected backcross of F_1 with D_1 dwarf segregated into 1 tall : 1 D_1 dwarf and with D_{11} dwarf into 1 tall : 1 D_{11} dwarf, respectively (Table 5). These observations confirmed that the D_1 and D_{11} dwarfness in pigeonpea was controlled by two different recessive genes t_4t_4 and t_5t_5, respectively in homozygous state.

Table 4. Pooled segregation for tall and D_{11} dwarf types within the tall F_3 segregating progenies from the crosses between D_{11} dwarf and three tall parents of pigeonpea

Cross	No. of F_3 progenies	Number of plants					Ratio tested	χ^2	P
		total	observed		expected				
			tall	dwarf	tall	dwarf			
D_{11} x ICPL 146	63	2216	1680	536	1662.0	554.0	3:1	0.779	0.30–0.40
D_{11} x ICPL 85024	149	5523	4161	1362	4142.3	1380.7	3:1	0.339	0.50–0.60
D_{11} x ICPL 85037	32	1097	833	264	822.7	274.3	3:1	0.510	0.40–0.50
Pooled	244	8836	6674	2162	6627.0	2209.0	3:1	1.333	0.20–0.30

Table 5. Segregation pattern in F_1, F_2 and backcross between D_1 and D_{11} dwarfs of pigeonpea

Generation and cross	Number of plants							Ratio	χ^2	Probability
	total	observed			expected					
		tall	D_{11} dwarf	D_1 dwarf	tall	D_{11} dwarf	D_1 dwarf			
$F_2: D_1 \times D_{11}$	1482	830	266	386	833.6	277.9	370.5	9:3:4	1.166	0.60–0.70
BC : $F_1 \times D_1$	27	15	—	12	13.5	—	13.5	1:1	0.333	0.50–0.60
BC : $F_1 \times D_{11}$	23	13	10	—	11.5	11.5	—	1:1	0.391	0.50–0.60

The d_{11} dwarf provides an additional source of dwarfness in pigeonpea. Unlike ICPL 85059 (D_1 dwarf) its branches are not brittle. However, its usefulness and linkages with other characteristics has yet to be studied.

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