Thoeretical and Applied Genetics 47, 115-118 (1976)

Some Induced Dwarfing Genes Non-Allelic to Dee-Geo-Woo-Gen Gene in Rice, Variety Tellakattera

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Summary. The allelic nature of five dwarfs (d6, d7, d8, d9 and d10), recovered in M2 after ethyl methanesulphonate treatment of a local rice variety Tellakattera, was studied in relation to the Dee-geo-woo-gen (DGWG) dwarfing gene. The behaviour of the different crosses of the dwarfs with DGWG in F1 and the segregation pattern in F2 clearly demonstrate that these induced dwarfs are non-allelic to the DGWG dwarfing gene. In view of the extensive use of this gene in developing most of the high yielding rice varieties, the new dwarfing genes of Tellakattera may be exploited as alternative sources, to avoid genetic vulnerability.

The semidwarf, photo-insensitive, high-yielding varieties with short erect leaves have greatly revolutionized rice yields in recent years, especially in the tropics (Athwal 1971). However, most of the newly developed high-yielding indica varieties of the tropics utilize Dee-geo-woo-gen (DGWG) dwarf as one parent (Chandler 1968) and, to avoid genetic suffocation, new sources of short-statured types are highly desirable. The allelic nature of several semidwarfs from the World Germ Plasm Collection was tested and, surprisingly, these semidwarfs were found to be allelic to DGWG, except for K8 and Cheng-chu-ai-11 (Anon. 1971, 1973).

Induced dwarf types may offer an alternative source for direct or indirect use in the improvement of rice. The induced lodging-resistant semidwarf variety 'Reimei', recovered from a tall variety 'Fujiminori' after gamma irradiation (Futsuhara et al. 1967), and the scented semidwarf Basmati, recovered after treatment with diethyl sulphate from a tall variety HR-47 with superior yield (Reddy and Reddy 1971), demonstrate the usefulness of induced mutants for direct cultivation.

The present study mainly deals with dwarfs recovered from a local rice variety Tellakattera (TK) and their relationship to the DGWG dwarfing gene, with a view to developing non-allelic dwarf varieties to avoid genetic vulnerability.

Materials and Methods

A tall growing (120 cms.), early maturing (about 100 days) local rice variety Tellakattera (TK) was treated with different concentrations of ethyl methanesulphonate and several semidwarfs and dwarfs were recovered in the M2 (Reddy et al. 1975). Five of these dwarf mutants which were morphologically distinct, exhibiting differences in the pattern of reduction in internode length, flag leaf and panicle characteristics, were selected in the M3 generation and were found to breed true even in the M8 generation.

In the japonica rice variety, twelve dwarfing genes have been identified and assigned to seven different linkage groups (Takahashi 1964; Hsieh and Yen 1966; Takahashi and Kinoshita 1968). Although several genes for dwarfing in the indica rice variety have been reported, the allelic relationship of these dwarfing genes has not been studied except for the five dwarfing genes designated d1 to d5 (Kadam 1937; Anon. 1963). In view of this, the present dwarfs recovered may be tentatively designated as d6 to d10, i.e. dwarf-6 (d6-74 cms.), dwarf-7 (d7-71 cms.), dwarf-8 (d8-77 cms.), dwarf-9 (d9-69 cms.) and dwarf-10 (d10-56 cms.).

All the mutants were crossed with DGWG dwarf in the M6 generation and the F1 plants were raised in pots together with the parents during January to May. The F2 plants of all the crosses were grown in the field, 15 × 15 cms. between plants and between rows, within a single block, in the following two seasons from July to October and January to May. The parents involved in the specific cross were grown on either side of the block with the F2 population. The heights of the plants (up to the longest leaf) were recorded at maturity. The mean heights of the parents and the variation are represented in Fig. 1. The segregating plants were grouped with a class interval of 10 cms. to observe the frequency distribution for height. The total frequencies of segregating tall and dwarf plants were obtained, based on the mean height and the range of the parents, and the segregating height classes were apparent from the distribution curve. The χ^2 and probability of goodness of fit for the observed segregation ratio was calculated. The segregation ratio, in all the crosses were consistent over the two seasons.

Results and Discussion

The plant height in F1 for all the crosses of TK dwarfs and TK control with DGWG was tall, ranging in mean height from 118.56 to 126.43 cms., observed in the d8 and d7 crosses, respectively. The

Table 1. Frequency distribution for height in crosses of Tellakattera control and dwarfs with DGWG in F2

Parents/F_1/F_2	21 -30	-40	-50	-60	-70	-80	-90	-100	-110	-120	-130	-140	-150
DGWG							35	110	5				
TK Control										4	54	2	
TKC × DGWG F_1										5	15	8	1
TKC × DGWG F_2				4	3	33	60	73	50	36	82	115	115
Dwarf-6				4	16	36	2						
d6 × DGWG F_1										8	9	3	
d6 × DGWG F_2			5	18	60	82	61	63	82	93	108	50	18
Dwarf-7				2	25	30							
d7 × DGWG F_1										1	13	3	
d7 × DGWG F_2				6	16	49	111	99	43	71	149	119	61
Dwarf-8					6	54							
d8 × DGWG F_1									4	18	5		
d8 × DGWG F_2				4	16	37	66	73	72	110	101	104	40
Dwarf-9				8	48	4							
d9 × DGWG F_1										7	8		
d9 × DGWG F_2		1	11	28	26	45	75	64	40	71	95	71	35
Dwarf-10			23	37									
d10 × DGWG F_1									2	9	8	1	
d10 × DGWG F_2	1	22	76	37	43	43	59	46	49	6	27	8	

number of plants analysed in F2 in all these crosses varied from 471 to 760. The frequency distribution for height for plants segregating in the cross of TK control with DGWG ranged from 60 to 200 cms. In crosses of d6, d7 and d8 with DGWG, the segregating plants ranged in height from 50 or 60 cms. to 170 or 180 cms. In the cross of d9 with DGWG the height ranged from 40 to 180 cms. and in the cross of d10 with DGWG the range observed was 30 to 140 cms. In crosses of DGWG with TK control, d6, d7, d8 and d9, two modes were apparent in the distribution: the frequency of plants segregating in the class 120 cms. in the cross TK control with DGWG; and the class 110 cms. in crosses of DGWG with d7, d8 and d9, and the classes 90 to 100 cms. in the cross of d6 with DGWG, demarcated the two segregating groups of tall and short plants in the distribution (Fig. 1). A higher frequency of tall plants was observed to segregate in the classes 140 and 150 cms. in the cross of TK control with DGWG; in the crosses of d6, d7, and d9 with DGWG the maximum frequency of tall plants was observed in the class 130 cms., and in the class 120 cms. in the cross of d8 with DGWG, while three modes were observed in d10 crosses with DGWG in the classes 50, 90 and 120 cms.

In the cross of TK control, the tall parent, with DGWG, the frequency distribution curve showed two distinct segregating classes of short and tall plants. When the cumulative frequency of plants segregating above and below 110 cms. was considered, the total numbers of tall and short plants observed were 529 and 173, respectively, giving a 3:1 segregation ratio (p = 0.80 to 0.90). This clearly shows that the DGWG behaves as a single recessive gene with respect to the tall TK parent used as control. Similar observations were made in earlier studies in crosses of DGWG with tall parents (Chang et al. 1965).

In view of the segregating classes of tall and short plants in the cross of TK control with DGWG, when 110 cms. was taken as the limit for segregating tall and short plants in all the crosses of TK dwarfs with DGWG (since DGWG was used as the common parent), it was observed that in d6 and d9 with DGWG, the segregation ratio for tall and short plants was 9:7, probability 0.50 to 0.70 and 0.90 to 0.95, respectively; in the crosses of d7 and d8 with DGWG the probability for this segregation ratio was very low when 110 cms. was considered. However, when 100 cms. was considered as the limit for the two segregating groups of tall and short plants in the crosses of d7 and d8 with DGWG, a greater probability for the 9:7 segregation ratio was realised, 0.50 to 0.70 and 0.25 to 0.50, respectively; whereas in the crosses of d10 with DGWG the probability of a 9:7 segregating plants were considered above and below 90 cms. (Table 1).

-160	-170	-180	-190	191 -200	Total	Mean ht. Cm.	Observed frequency		Ratio χ^2	P-Value
							Tall	Dwarf		
					150	94.70				
					60	123.30				
					30	120.63				
78	33	18	-	2	702	--	529	173	3:1 0.048	0.80-0.90
					58	73.95				
					20	121.28				
7	2				649	--	360	289	9:7 0.61	0.50-0.70
					57	71.29				
					17	126.43				
29	7				760	--	436	324	9:7 0.388	0.50-0.70
					60	77.63				
					27	118.56				
18	6	1			648	--	380	268	9:7 1.507	0.25-0.50
					60	65.00				
					15	121.38				
11	3	1			577	--	327	250	9:7 0.029	0.90-0.95
					60	56.27				
					20	124.26				
					471	--	249	222	9:7 2.063	0.10-0.20

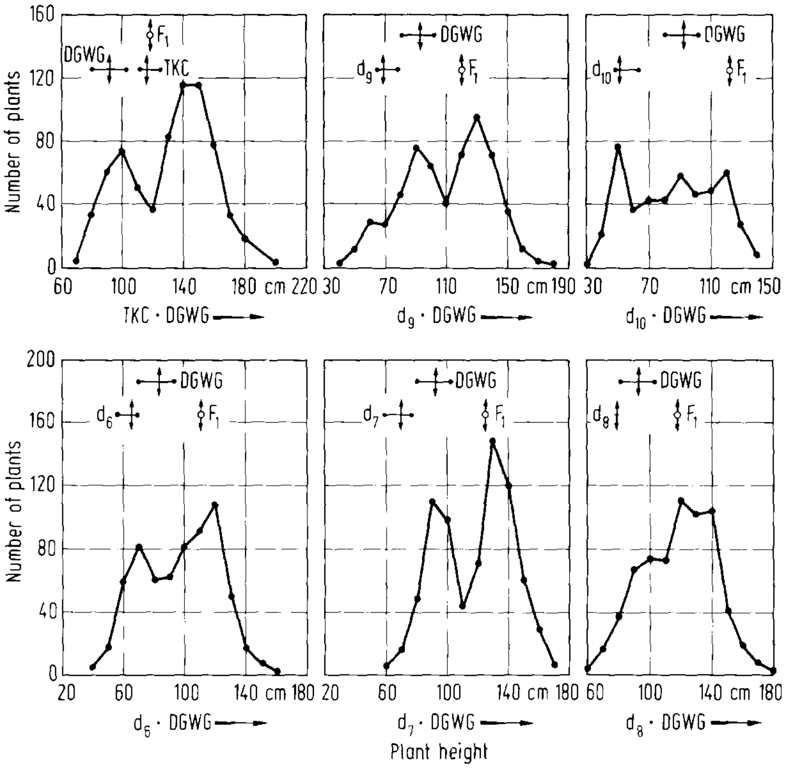

Fig. 1. Frequency distribution curve for height in F2 in crosses of dwarfs of Tellakattera and control with DGWG

In crosses of the five dwarfs with the tall parent, TK control, a clear segregation for a 3:1 ratio of tall and dwarf plants showed that the dwarfs are controlled by single recessive genes. In further crosses among these dwarfs, tall plant height in F1 and dihybrid or modified dihybrid segregation ratios suggested complementary behaviour for these dwarfing genes; this work will be published elsewhere.

The complementary behaviour of each of the TK dwarfs for tall height in F1 in crosses with DGWG, and the dihybrid segregation ratio of 9:7 in F2 with varying probabilities, suggest that the five dwarfing genes of Tellakattera are non-allelic to the DGWG dwarfing gene.

In the crosses involving the DGWG dwarf with TK control and other dwarfs, a transgressive segregation was observed in F2. The transgression was maximal in crosses of DGWG with the TK control, the tallest parent, which varied from 60 to 200 cms., while in crosses of dwarfs d6, d7 and d8 with DGWG the transgression varied from 50 or 60 cms. to 170 or 180 cms. It varied from 40 to 180 cms. in the cross of d9 with DGWG and from 30 to 140 cms. in the cross of d10 with DGWG. Such transgressive segregation observed in crosses involving the DGWG dwarf was explained by the epistatic interaction of the modifier genes present in the DGWG background (Chang et al. 1965).

The selection of different dwarfing genes from the locally adapted varieties for the breeding programme may be very useful in the development of new short-statured varieties. Such induced short-statured mutants have been found to perform better than the parent variety (Hu 1973).

The rapid spread of high-yielding varieties like IR-8, Jaya etc., especially in India, with the DGWG dwarfing gene, introduces the danger of constantly exposing the same background to the adaptation of specific pathogens. The introduction of different dwarfing loci may insure against this. The five TK dwarfing genes d6, d7, d8, d9 and d10, which are non-allelic to the DGWG dwarfing gene, may be exploited in developing new varieties aimed at avoiding genetic vulnerability. Besides, these dwarfs, recovered from a locally well adapted short duration variety Tellakattera, may prove to be more advantageous in developing high-yielding varieties.

Acknowledgements

We are grateful for the partial financial assistance provided by the USPL-480 grant No. FG-IN-533 (IN-ARS-19), for the University Grants Commission's Research Fellowship and Junior Scientific Assistantship in the above scheme to one of us (A.P.).

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Received August 4, 1975
Communicated by B.R. Murty

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