

GENIC ANALYSIS IN RICE

VII. Linkage Relations of an Induced Dwarfness Gene, $d^{42(1)}$

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A number of dwarfness genes have so far been known in rice, i.e., d_1 to d_8 by Nagao and Takahashi (1946, 1960); d_9 found by the senior writer (Hsieh 1962) was renumbered as d_{31} by Chang and Jodon (1963), in view of necessity of conforming gene symbolization. The writers are engaged in analysis of those dwarf genes. This paper deals with the results of crossing experiments with H106, a dwarf strain derived from a cross between a radiation-induced dwarf (C-2180, from Taichung 155) and a liguleless strain, Pai-kan-tao. All these strains belong to the *Japonica* type. H106 is about 25 cm high at maturity, the leaves being narrow and dark green, and has no ligule, no auricle and no junctura.

Results and Discussion

When H106 was crossed with 9 normal strains of either *Japonica* or *Indica* type, the F_2 's invariably showed a 3 normal: 1 dwarf ratio, though in some crosses a few plants were intermediate in height between parents. Its dwarfness is due to a recessive factor, as is generally the case with other spontaneous or induced dwarf strains. The dwarf F_2 segregants mostly had narrow and dark-green leaves, suggesting pleiotropic effects on leaves of the dwarfness gene concerned.

H106 was then crossed with three other dwarf strains, D-65-1 (induced from Taichung 155) and 7247 (having broad and dark-green leaves, obtained through the kindness of Mr. N.E. Jodon.) These strains are known to have different genes for dwarfness. All the F_1 hybrids showed normal height, and the F_2 s segregated into 9 normal, 3 H106-type dwarf, 3 dwarf resembling the

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Table 1. *List of strains used*

Strains	Local name	Classification	Genetic characters	Putative genic constitution	Source
J 301	Yoshino no. 1	<i>Japonica</i>	Apiculus ripening brown	.	Japan
J 302	Nakamura	<i>Japonica</i>	Apiculus ripening brown		Japan
J 310	Lun-shen-tao	<i>Japonica</i>	Apiculus ripening brown		Japan
J 311	Hatsu-nishiki	<i>Japonica</i>	Apiculus ripening brown		Japan
J 317	Sensho	<i>Japonica</i>	Apiculus ripening brown		Japan
J 327	Kinoshitamochi	<i>Japonica</i>	Glutinous endosperm	<i>C A wx</i>	Japan
H-61	Nagao and Takahashi's strain	<i>Japonica</i>	Dwarf	<i>C^{Bb}A p d₂ I-Bf</i>	Japan
P123	Taichung no. 65	Ponlai (<i>Japonica</i>)	Apiculus ripening brown	<i>C^Br a</i>	Taiwan
D-65-15	Mutant from Taichung no. 65	Ponlai (<i>Japonica</i>)	Tillering dwarf	<i>C^Br a d</i>	Taiwan
D-155-1	Mutant from Taichung no. 155	Ponlai (<i>Japonica</i>)	Dwarf	<i>C a d</i>	Taiwan
H106	Dwarf mutant × Pai-kan-tao	Ponlai (<i>Japonica</i>)	Narrow-leaved dwarf, liguleless	<i>d₄₂ lg</i>	Taiwan
T203	I-kung-pao	<i>Indica</i>	Positive phenol reaction	<i>Ph</i>	Taiwan
T237	Wo-lang-chu	<i>Indica</i>	Positive phenol reaction	<i>Ph wx</i>	Taiwan
M506	Kun-san-wusian-ken	<i>Japonica</i>	Purple hull	<i>C^B A Pr</i>	China mainland
7102	Jodon's strain	Medium grain	Purple leaf blade, hull and pericarp	<i>C A Pr Pl Pp Pb</i>	U. S. A.
7227	Jodon's strain	Medium grain	Glutinous endosperm	<i>wx</i>	U. S. A.
7247	Jodon's strain	Medium grain	Broad leaved dwarf	<i>d</i>	U. S. A.

other parent, and 1 double-dwarf. The very short double-dwarfs bred true in succeeding generations.

The ligulelessness of H106, derived from Pai-kan-tao, was found to be due to *lg*, the same gene as found in other liguleless *Japonica* strains. According to Seetharaman (1964), the ligulelessness gene of *Indica* strains would also be at the same locus, because, when they were crossed with *Japonica* liguleless strains, the *F*₁ plant were liguleless.

It was found that the dwarfness gene of H106 (*dx*) was linked with *lg*. Therefore, *dx* would belong to linkage-group II of Nagao and Takahashi (1952, 1960). The recombination value between *dx* and *lg*, computed by the maximum likelihood method, ranged from 6.8% to 12.3% among 17 cross-combinations observed, as shown in Table 2.

Table 2. Linkage between the dwarf gene *dx* of H106 and the liguleless gene *lg*

Crop season	F ₁ fertility	Crosses	Combined character				Total	Recombination value	X ²	P
			AB	Ab	aB	ab				
1962-I	40	<i>Japonica</i> × <i>Indica</i> H106 × T237	208	14	21	56	299	12.57 ± 1.40	1.43	0.5-0.7
1962-II	40	H106 × T237	199	15	20	65	299	11.96 ± 1.37	2.00	0.5-0.7
1962-I	45	H106 × T203	217	18	15	50	300	12.27 ± 1.38	1.78	0.5-0.7
1962-II	91	<i>Japonica</i> × <i>Japonica</i> H106 × P123	213	11	16	57	297	8.81 ± 1.17	0.69	0.8-0.95
1962-II	82	P123 × H106	197	11	11	55	274	8.99 ± 1.18	0.21	0.95-0.98
1964-I	83	H106 × J301	224	15	12	44	295	10.56 ± 1.34	5.80	0.10-0.20
1964-I	73	H106 × J302	214	12	10	64	300	7.62 ± 1.08	0.18	0.98-0.99
1964-I	76	H106 × J310	168	12	14	49	243	11.25 ± 1.47	0.20	0.95-0.98
1964-I	82	H106 × J311	218	15	16	50	299	11.66 ± 1.35	1.82	0.5-0.7
1964-I	88	H106 × J317	101	9	5	34	149	9.15 ± 1.68	1.79	0.5-0.7
1964-I	72	H106 × J327	233	14	11	39	297	10.04 ± 1.25	10.96	0.01-0.02
1964-I	88	H106 × M506	171	11	14	53	249	10.38 ± 1.45	0.24	0.95-0.98
1962-I		D-65-15 × H106	208	9	18	65	300	8.78 ± 1.16	2.55	0.3-0.5
1962-I		D-155-1 × H106	103	5	8	34	150	8.58 ± 1.63	1.10	0.7-0.8
1962-II		<i>Japonica</i> × <i>U. S. strains</i> H106 × 7227	120	5	4	24	153	6.80 ± 1.43	3.73	0.3-0.5
1962-II		7102 × H106	157	11	16	48	232	12.10 ± 1.55	1.28	0.7-0.8
1964-I	93	H106 × 7247	219	9	12	46	286	8.34 ± 2.88	5.09	0.1-0.2
Total			3170	196	223	833	4422	10.19 ± 1.03	7.20	0.05-1.0

Note: 1962-I 1st crop of 1962

1962-II 2nd crop of 1962

Table 3. Estimation of recombination value between *Ph* and *lg* in F_2 of $H106 \times T203$

F ₁ genotype	Classes	Combined character				Total	Recombination value	X ²	P
		<i>Ph Lg</i>	<i>Ph lg</i>	<i>ph Lg</i>	<i>ph lg</i>				
$\frac{ph-lg}{Ph-Lg}$	Observed	205	19	22	45	291	15.99±1.61	1.392	0.7-0.8
	Expected	(196.85)	(21.4)	(21.4)	(51.35)				

Table 4. Estimation of recombination value between *dx* and *Ph* in F_2 of $H106 \times T203$

F ₁ genotype	Classes	Combined character				Total	Recombination value	X ²	P
		<i>D Ph</i>	<i>D ph</i>	<i>d Ph</i>	<i>d ph</i>				
$\frac{Dx-ph}{dx-Ph}$	Observed	214	21	11	54	300	11.11±1.31	3.760	0.3-0.5
	Expected	(206.26)	(15.74)	(15.74)	(59.26)				

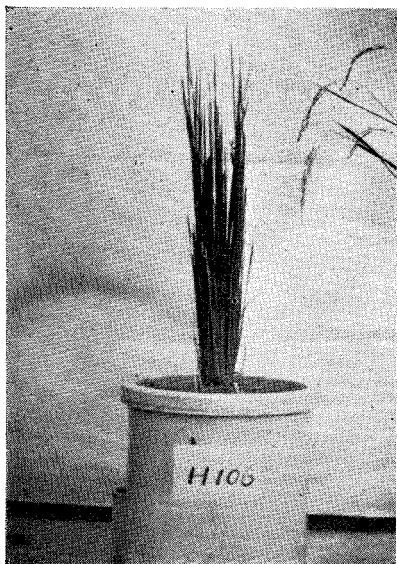


Fig. 1. A dwarf strain, H106 (d_{42}) standing in pot.

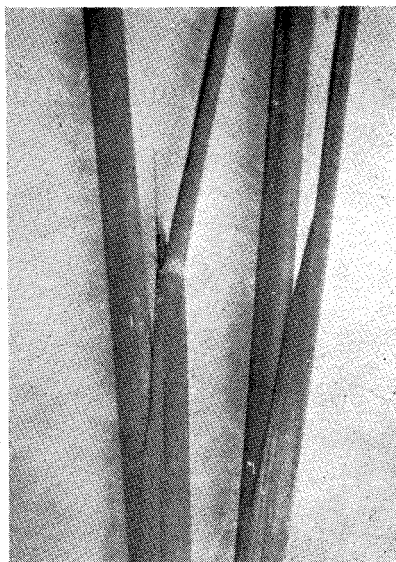


Fig. 2. The liguled (left) and liguleless (right) plants

The dwarfness gene dx was found further to be linked with the phenol-reaction gene Ph , with a $11.1 \pm 1.31\%$ recombination fraction (in H106 \times T203). The recombination fraction between Ph and lg in this cross was $15.9\% \pm 1.61\%$, though according to Nagao and Takahashi (1952, 1960), it is 7.4% . It therefore seems probable that dx is located between lg and Ph . In this linkage group, two other dwarfness genes, d_2 and d_3 are known to be arranged as follows (Nagao and Takahashi 1960):

25.4	39.7	10	11.1	
d_2	d_3	lg	(d_{42})	ph
47.2		7.4		
		15.9		

When H106 was crossed with d_2 (H-61, obtained through the kindness of Dr. M. Takahashi), F_1 was normal, and segregation of plant height was seen in F_2 . d_3 (Ebisu dwarf) is of a relatively minor effect; d_3 is one of multiple genes for tillering dwarf. Our dx seems to be identical neither with d_2 nor with d_3 . Tentatively, it may be named d_{42} , as suggested by Dr. T.T. Chang of IRRI, the monitor of gene symbols in rice.

Summary

A dwarf and liguleless strain H106, derived from a cross between an induced dwarf and a liguleless strain, was crossed with 15 different strains, with the view to finding out linkage relations of the dwarfness gene concerned.

The dwarfness gene, tentatively named d_{42} , was found to be located between lg and Ph in linkage group II of Nagao and Takahashi. The recombination value between d_{42} and lg ranged from 6.8% to 12.3% according to cross-combinations.

稻之遺傳因子分析

第七報 一突變矮稻遺傳因子 d_{42} 與其他性狀之連鎖

謝 順 景 嚴 威 添

突變稻 H106 係由一原子能處理後代 C-2180 與稈稈稻雜交後代所產生的無葉舌、無葉芽、細葉、高約25cm的矮稻系統。為明瞭此系統之矮性遺傳因子與其他遺傳因子間之關係乃將本系統與屬於日本型稻，印度型稻及美國稻之16品系雜交。經研究其 F_2 結果得知，支配本矮稻之遺傳因子 dx 與無葉舌因子 lg ，石炭酸反應因子 Ph 之間有連鎖關係。其交換值 dx 與 lg 之間隨雜交組合而介於 6.8~12.3% 之間，平均為10%， dx 與 Ph 之間為 11.1%， lg 與 Ph 之間為 15.9%，此三對遺傳因子，均位於長尾及高橋(1960)之第二連鎖羣。經雜交結果認為 dx 與長尾與高橋(1960)之 d_2 與 d_3 不同，故根據國際稻米研究所張德慈博士之建議，將本矮稻之遺傳因子暫定為 d_{42} 。

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