Spontaneous Mutant Showing Pale Seedling Character in Watermelon [*Citrullus lanatus* (Thunb.) Matsum. and Nakai]

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The pale seedling character in watermelon was reported first in 1979 (1). The pale leaf trait was hypothesized to be controlled by a pair of recessive genes interacting with a single dominant gene (2). The name, delayed green, was proposed for this trait and the symbols *dg* and *I-dg* were proposed for the recessive and dominant genes, respectively (3). Until 1996, it was reported that the dominant allele *I-dg* inhibits the expression of the gene *dg*, since the F_2 populations fit a 13:3 ratio and backcross progeny fit 1:1 ratio (2, 3, 4). But in 1996, it was reported that delayed green is inherited as a single recessive nuclear gene (5).

In 1998, I found a spontaneous mutant which showed a pale seedling character. This study was undertaken to verify the inheritance.

Material and Methods: A spontaneous mutant that shows pale seedling character was found in a breeding line in 1998 in Korea. This line originated from a cross between a yellow-fleshed breeding line and red-fleshed one. In 1992, a cross between the yellow-fleshed line and red-fleshed line, and the backcross of this F_1 to red-fleshed line was made. From 1993, self-pollination was made twice per year to make inbred lines. In the spring of 1998, 5 mutants that showed the pale seedling character out of 10 progeny were found in F_{11} generation and seeds were obtained from all mutants. In the fall of 1998, the crosses were made between pale leaf plants and normal plant of 5 elite lines. In the spring of 2002, F_1 seeds were planted and pollinations were made to obtain backcross and F_2 progeny.

Results and Discussion: In the crosses between pale leaf plants and normal plant of 5 elite lines, the F_1 progeny did not show the trait. The results of the progeny test are recorded in Table 1. In the F_2, a total 488 of 1438 seedlings were scored as pale leaf. The F_1 plants backcrossed with the pale leaf male parent produced a total of 996 pale leaf seedlings were found in a population of 2021 plants. The F_2 population fit a 3:1 ratio (χ^2 = 0.117) and the backcross progeny fit 1:1 ratio (χ^2 = 0.416). These data suggest that the pale seedling character is inherited as a single recessive nuclear gene.

The name, delayed green, and the symbol, *dg*, for pale leaf trait were proposed first in 1986 by Rhodes (3). It is not certain whether the pale leaf trait described here shows the same phenotype with that of the delayed green trait or not. Further study is needed to clarify the relationship of both traits.

The pale leaf trait can be detected at the cotyledon stage by color (Figure 1a). The difference between pale cotyledon and normal one is sometimes not clear when the soil is dry. In the stage of second true leaf, the distinction is more obvious (Figure 1b). The old leaf of pale seedlings becomes more greenish after transplanting, but it is still less green than normal (Figure 1c).

The mutant was first observed in 5 of 10 plants in F_{11} generation. It is suggested that the pale leaf gene (tentatively marked as *pl*) occurred in the F_{10} generation and the mutation occurred in one of the two germ cells from a plant of the F_9 generation or as a somatic mutation from a plant of F_{10} generation (Figure 2). The first alternative could result from unequal crossing-over or another type of minute chromatin loss, gain, or qualitative change at meiosis; the second could result from failure of minute chromatin duplication, loss of a minute chromatin fragment, or a qualitative change during meiosis.

Literature Cited:

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Table 1. Segregation for the pale seedling character in the F_2 and backcross populations

Generation	No. of observed plant		Expected ratio	χ^2	Probability
	Green	Pale			
F2					
Pale x Line A	294	102	3:1	0.121	0.750>P>0.500
Pale x Line B	405	135	3:1	0.000	P>0.950
Pale x Line C	264	90	3:1	0.034	0.900>P>0.750
Pale x Line D	277	95	3:1	0.057	0.900>P>0.750
Pale x Line E	198	66	3:1	0.000	P>0.950
Total	1438	488	3:1	0.117	0.750>P>0.500
BC					
(Pale x A) (Pale)	225	218	1:1	0.111	0.750>P>0.500
(Pale x B) (Pale)	290	284	1:1	0.063	0.900>P>0.750
(Pale x C) (Pale)	185	179	1:1	0.099	0.900>P>0.750
(Pale x D) (Pale)	192	185	1:1	0.130	0.750>P>0.500
(Pale x E) (Pale)	133	130	1:1	0.034	0.750>P>0.500
Total	1025	996	1:1	0.416	0.750>P>0.500

Figure 1. Comparison of pale green seedlings with normal one: (left) Top, pale leaf seedling at the cotyledon stage. Bottom, normal, (middle) Top, pale green seedling at the second true leaf stage. Bottom, normal, (right) Left, pale leaf seedling at the pollination stage. Right, normal.

Year	Season	Generation	Progeny-plant	Putative genotype
1992	spring	F_1		
1992	fall	BC_1		
1993	spring	F_2	HY477-3	+/+
			↙-sibs	+/+
1993	fall	F_3	HY477-3-11	+/+
			↙-sibs	+/+
1994	spring	F_4	HY477-3-11-7	+/+
			↙-sibs	+/+
1994	fall	F_5	HY477-3-11-7-11	+/+
			↙-sibs	+/+
1995	spring	F_6	HY477-3-11-7-11-2	+/+
			↙-sibs	+/+
1996	spring	F_7	HY477-3-11-7-11-2-4	+/+
			↙-sibs	+/+
1996	fall	F_8	HY477-3-11-7-11-2-4-1	+/+
			↙-sibs	+/+
1997	spring	F_9	HY477-3-11-7-11-2-4-1-3	+/+
			↙-sibs	+/+
1997	fall	F_{10}	HY477-3-11-7-11-2-4-1-3-2	+/*pl*
			↙-sibs	?/?
1998	spring	F_{11}	HY477-3-11-7-11-2-4-1-3-2-5	+/*pl*
			-1	*pl*/*pl*
			-3	*pl*/*pl*
			-8	*pl*/*pl*
			-9	*pl*/*pl*
			-10	*pl*/*pl*
			-sibs	?/?

Figure 2. The suggestive origin for the recessive allele (*pl*) responsible for the pale seedling character of mutant found in 1998 in Korea