GENETIC RELATIONS AMONG THE MALE STERILE CYTOPLASMS FOUND IN ASIAN RADISHES (RAPHANUS SATIVUS L.)

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ABSTRACT

Cytoplasms of male sterile Asian radishes were compared with that of Ogura by the PCR analysis of mtDNA and the segregation in the progenies. Japanese wild radishes contain the cytoplasm identical to Ogura. Several Asian cultivars also have the Ogura cytoplasm or the modified type, but the phenotypic expression by the test-crosess varied among the strains.

INTRODUCTION

Male sterile cytoplasm of Ogura is known to have a lot of rearrangements in mitochondrial DNA(mtDNA) compared with the normal one. By the assay with PCR technique using the differences in atp6 as primers, we found that the Ogura mitochondria is distributed widely in Japanese wild radishes, although almost all of them are male fertile (Yamagishi & Terachi, 1994a,b). In order to detect the identity of the male sterility with that of Ogura, the segregation of the phenotype was analysed in the progenies between the wild radish having the Ogura type atp6 and the maintainer and restorer of the Ogura male sterility.

On the other hand, by the observation of anther development for about 400 plants of 80 Asian cultivars and strains, we found the several male sterile plants. After the analysis of the mtDNA by the PCR with primers in the loci of atp6 and orf138, the sterile plants were crossed with the maintainer and the restorer of Ogura. The phenotype of the hybrids was observed and the segregation patterns were studied in regard to that of Ogura.

MATERIALS AND METHODS

Wild radish plants having Ogura type atp6 in mtDNA, which were collected in Tomioka, Kumamoto, were used as cytoplasm parents. We crossed the plants with 'Uchiki-Gensuke', the maintainer of the Ogura male sterility. By the back-cross of the F_1s with 'Uchiki-Gensuke', segregation of male fertility was observed. The fertile and sterile plants of this back-crossed progeny (hereafter TUU-F and TUU-S, respectively) were used for the test crosses. Table 1 shows the cross combinations. For the progeny plants, the anther development was observed.

We found the male sterile plants in the wild radish(Iwasaki) and the cultivars (Daibaika, Kosena, etc.). Their mtDNAs were analysed by PCRs using the primers specific to the normal type and Ogura type atp6, and Ogura specific orf138. The sterile plants were crossed with 'Comet' (the fertility restoring cultivar on Ogura cytoplasm) and 'Uchiki-Gensuke'.

RESULTS AND DISCUSSION

Table 1 summarizes the mtDNA type of the female parents and the segregation of fertility in the progenies. In the self-pollinated progeny of TUU-F and the crossed progeny between TUU-S and TUU-F, the segregation of fertility was observed. The ratio fitted well to the expected one from the hypothesis that a single dominant gene controls the fertility. By the cross of TUU-S with `Comet`, all the progeny plants showed normal fertility. Further, the fertile and sterile plants were segregated in the 1:1 ratio in the progeny between `MS-Gensuke`(male sterile plant having Ogura cytoplasm) and TUU-F. These results indicate that the cytoplasm of the wild radish coincides with that of Ogura, and that the wild radish has the restoring gene effective on the Ogura male sterile cytoplasm. The Ogura cytoplasm therefore, is concluded to have been introduced from the Japanese wild radish.

The PCR aided mtDNA assays of the sterile plants revealed that there are two types of DNA in the orf138 locus, despite all the plants have Ogura type atp6. One DNA type which was expected to Ogura cytoplasm was found in `Daibaika-3`, while another type with smaller molecular weight, was contained in `Iwasaki-S` and `Kosena-4`. It was clarified by the sequencing studies that the latter type deletes 39 nucleotides in orf138.

In the progeny between `Daibaika-3` and `Comet`, all the plants showed the normal development of anthers. This means the sterility of the female parent was restored by `Comet`. However, by the crosses of `Iwasaki-S × Comet` and `Kosena-4 × Comet`, the segregation of fertility was observed, though the segregation ratio can not be estimated because of the small number of the progeny plants. Similarly, in the two crosses with the maintainer of Ogura male sterility, `Uchiki-Gensuke`, the segregation of fertility was found, except that all were sterile in `Iwasaki-S × Uchiki-Gensuke`.

TABLE 1. MtDNA type and male fertility of the radishes and the segregation of the fertility in the progenies of them.

Cytoplasm parent				Pollen parent	Segregation	
Strain	Fertility	atp6	orf138[a]		Fertile	Sterile
TUU-F[b]	Fertile	Ogura	Ogura	Self-pollination	71	34
TUU-S	Sterile	Ogura	Ogura	TUU-F	48	53
TUU-S	Sterile	Ogura	Ogura	Comet	9	0
MS-Gensuke	Sterile	Ogura	Ogura	TUU-F	6	6
Daibaika-3	Sterile	Ogura	Ogura	Comet	8	0
Iwasaki-S	Sterile	Ogura	Ogura'	Comet	1	4
Kosena-4	Sterile	Ogura	Ogura'	Comet	4	3
Daibaika-3	Sterile	Ogura	Ogura	Uchiki-Gensuke	2	2
Iwasaki-S	Sterile	Ogura	Ogura'	Uchiki-Gensuke	0	9
Kosena-4	Sterile	Ogura	Ogura'	Uchiki-Gensuke	3	8

a Ogura': Smaller molecular weight of DNA than that of Ogura.
b TUU-F: Fertile plant of (Tomioka × Uchiki-Gensuke) × Uchiki-Gensuke.
TUU-S: Sterile plant of (Tomioka × Uchiki-Gensuke) × Uchiki-Gensuke.

From these results, it is indicated that male sterile cytoplasm of Ogura or the modified type is distributed in Asian radishes besides the Japanese wild ones, but that the genetic control system of the expression of the male sterility is different among the strains having the cytoplasm.

REFERENCES

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