

DETERMINATION OF RESTORER GENES FOR SOURCES OF CYTOPLASMIC MALE STERILITY IN WILD SUNFLOWER SPECIES

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INTRODUCTION

The discovery of a stable source of cytoplasmic male sterility (CMS) by Leclercq (1969) fulfilled the basic requirement for practical utilization of heterosis in sunflowers. The second requirement was met by the discovery of restorer genes by Kinman (1979). Later on, a number of researchers have discovered restorer genes for CMS PET 1 (Leclercq, 1971; Vranceanu and Stoenescu, 1971; Fick et al., 1974; Škorić et al., 1978; etc.).

Discoveries of new sources of CMS have called for discoveries of corresponding restorer genes. CMS Indiana-1, discovered by Heiser (1982), is restored by RHA 265 and RHA 266, the premier restorers discovered by Kinman (1970); fertility restoration genes are found in HA 89, and other genotypes.

A new CMS source, CMG-1, discovered by Whelan (1980), calls for fertility restoration different from that needed for the previously discovered CMS sources. Some results indicate that there are two dominant complementary genes in question, other results point at two or three independent genes. The second CMS source discovered by Whelan (1981), CMG-2, is restored to full fertility by "Bd 2al". Fertility restoration sources have not been published for the third source, CMG-3, discovered by Whelan and Dorrell (1980).

Wolf and Miller (1985) transferred the genome of Ha 89 into cytoplasm of CMG-1, CMG-2, and CMG-3 and found that the line RCMG-2 possesses restorer genes for all three sources.

The seven CMS sources discovered by Serieys (1986) require different fertility restoration genes.

The objective of this investigation was to determine restorer genes for different CMS sources in wild sunflower species.

MATERIAL AND METHOD

The following CMS sources were used in this investigation: the standard CMS-PET-1, CMS-ANL-2 (CMS Indiana-1), CMG-1, CMG-2, CMG-3, and a Novi Sad source ANN-81. A stable A-sterile line was used for CMS-PET-1, A lines after BC_4 for CMS-ANL-2, CMG-1, CMG-2, and CMG-3, and a sterile BC line for ANN-81.

Sterile plants of the six CMS sources were crossed to wild sunflower species in the course of 1986. Pollen from wild species was applied two times to each sterile plant.

Seeds of the produced F_1 interspecific hybrids were sown in 1987. The actual number of plants varied in dependence of available amounts of hybrid seeds and their germination capacity, ranging from 5 to 100 plants.

Fertility restoration in the F_1 interspecific hybrids was checked in all plants at the stage of full flower. With some hybrid combinations, the presence of pollen, i.e., fertility restoration, could not be established in field. These plants were sampled and checked microscopically for the presence of pollen and its viability.

The tested materials were divided in two groups with respect to fertility restoration. The first group comprised the wild species and their populations with full restoration, the second those with fertility restoration in heterozygous form (fertile and sterile plants present in the F_1 generation).

RESULTS AND DISCUSSION

The fertility restoration genes for the six CMS sources were more frequent in the F_1 hybrids of the annual species (Table 1) than of the perennial ones (Table 2).

It was observed in several populations of wild species that some plants had restorer genes in homozygous state and the other plants had restorer genes in heterozygous state (Tables 1 and 2). It was concluded that pollen of individual plants should be used in fertility restoration studies insted of a mixture of pollen from several plants.

Not a single population of the studied wild species possessed a set of restorer genes for all six CMS sources. Some populations did contain genes for 3 - 4 sources. Within the annual wild species, restorer genes for the standard CMS source, CMS-PET-1, were most frequent, and those for CMS Indiana-1 were in the second place.

It should be pointed out that restorer genes for all six CMS sources were found in the populations of H.praecox, but these genes were predominantly in heterozygous state. Fertility restoration genes for CMG-2 and CMG-3 were also found in H.niveus. These genes were in heterozygous state.

Restorer genes for individual CMS sources were determined in 16 perennial wild species (Table 2).

A single population of H.decapetalus possessed restorer genes for CMG-1, CMG-2, and CMS-Indiana-1, in heterozygous state. Two H.divaricatus populations possessed restorer genes for CMG-1 and CMS-Indiana-1 in heterozygous state and a gene for CMG-3 in homozygous state. Several H.giganteus populations possessed restoration genes for CMG-1, CMG-2, CMS-Indiana-1, and ANN-81 in heterozygous state, and one population of the same species possessed a gene for CMS-PET-1 in homozygous state. Several H.grosseserratus populations possessed restoration genes for all CMS sources but ANN-81. H.glaucophyllus seems to possess restorer genes for only CMS-Indiana-1. Restorer genes for CMS-1 and CMS-PET-1,in heterozygous state, were found in H.hirsutus. H.laevigatus possessed restorer genes for CMG-1, CMG-2, and CMS-Indiana-1. H.maximiliani populations possessed restorer genes for all tested CMS sources except ANN-81. H.mollis possessed restorer genes for CMG-1, CMG-3, and CMS-Indiana-1. H.nuttallii populations possessed restorer genes for all tested CMS sources except CMG-2. H.occidentalis possessed restorer genes for CMG-1 and CMS-Indiana-1. H.resinosus populations possessed restorer genes for three CMS sources, CMG-1, CMS-Indiana-1, and CMS-PET-1. H.rigidus seems to possess restorer genes for only CMG-1 and CMG-2. It appears that H.smithii possesses restorer genes for only CMS-Indiana-1. H.strumosus was found to possess restorer genes for CMG-1 and CMS-Indiana-1. H.tuberosus populations possessed restorer genes for all tested CMS sources save CMG-2.

The obtained results do not give a complete picture of the presence of restorer genes for the tested CMS sources in wild sunflower species. Furthermore, it has not been found how many genes control fertility restoration in certain CMS sources and which genes are present in certain wild species.

CONCLUSIONS

Restorer genes were detected in six annual and 16 perennial wild sunflower species.
The frequency of restorer genes was much higher in the annual than in the perennial wild species.

Restorer genes for CMG-1 were registered in 19 wild species, for CMG-2 in 12 species, for CMG-3 in 11 species, for CMS-Indiana-1 in 19 species, for CMS-PET-1 in 12 species, and for ANN-81 in 7 species.

The registered restorer genes were more frequently in heterozygous than in homozygous state.

Certain populations of wild species possessed restorer genes for as much as four CMS sources. Restorer genes for three, two, or one CMS source were more frequent within populations of the same species.

The obtained results do not allow the determination of the number of genes controlling fertility restoration of the six CMS sources in the tested populations and species of wild sunflower.

LITERATURE

Fick, G.N., Zimmer, D.E., Dominquez, G.J., and Rehder D.A., 1974, Fertility restoration and variability for plant and seed characteristics in wild sunflower. Proc.of the 6th International Sunflower Conference: 333-339, Bucharest.

Heiser C.B., 1982, Registration of Indiana-1 CMS sunflower germplasm. Crop Science.

Kinman M.L., 1970, New developments in the USDA and State Experimental Station Sunflower Breeding Programs. Proc.of 4th International Sunflower Conference: 181-184, Memphis.

Leclercq P., 1969, Une sterilite male cytoplasmique chez le tournesol. Ann.Amelior. Plantes. 19(2): 99-106.

Leclercq P., 1971, La sterilite male cytoplasmique du tournesol. Premieres etudes sur la restauration da le fertilite. Ann.Amelior.Plant. 21:45-54.

Serieys A., 1986, Characterisation of some new cytoplasmic androsterilites sources from Helianthus genus. FAO Meeting. July 21-25, Sindes, Greece.

Škorić D., Ćuk L., Mihaljčević M., and Marinković R., 1978, New sources of fertility restoration (Rf genes) and downy mildew resistance (Pl genes) in sunflowers. Proc.of the 8th International Sunflower Conference: 423-426, Minneapolis.

Vranceanu A.V., Stoenescu F., 1971, Pollen fertility restorer gene from cultivated sunflower (H.annuus L.), Euphytica. Vol. 20,No 4: 536-541.

Whelan E.D.P., 1980, A new source of cytoplasmic male sterility in sunflower. Euphytica. 29: 33-46.

Whelan E.D.P., and Dorrell D.G., 1980, Interspecific hybrids betwen H.maximiliani Schrad. and H.annuus L. Effect of Backcrossing on Meiosis, Anther Morphology and Seed Characteristics. Crop Science.Vol.20:29-34.

Whelan E.D.P., 1981, Cytoplacmic Male Sterility in H.giganteus L. x H.annuus L. Interspecific Hybrids. Crop Science. Vol.21: 855-858.

Wolf S.L., and Miller J.F., 1985, Fertility restoration response of various sunflower cytoplasms. Proc.of the 11th International Sunflower Conference: 549-552. Mar Del Plata.

TAB. 1 DETERMINATION OF RESTORER GENES IN ANNUAL WILD SUNFLOWER SPECIES

SPECIES	CMS-a TYPE											
	CMG-1		CMG-2		CMG-3		Indiana-1		CMS-PET-1		ANN-81	
	Full restaur.	Hetero-zygous	Full restaur.	Hetero-zygous	Full restaur.	Hetero-zygous	Full restaur.	Hetero-zygous	Full restaur.	Hetero-zygous	Full restaur.	Hetero-zygous
ANN 1261										*		
ANN 1392				*	*			*				*
ANN 1427											*	
ANN 1490	*	*							*			
ANN 1513				*			*					*
ANN 1624		*							*			
ANN 1664	*		*	*					*	*	*	
ANN 1666		*	*					*		*		
ANN 1667-1								*	*			
ANN 16668-1							*	*	*			
ANN 1804								*				
ANN 413018		*					*		*	*	*	*
ANN 413042								*		*		*
ANN 413066			*				*	*	*		*	
ANN 413067			*	*	*							
ANN 413068		*	*				*	*				*
ANN 413177				*						*		
ARG-A			*							*		
ARG 415	*								*			
ARG 1575	*	*	*	*			*		*	*		
ARG 1675	*		*			*	*	*	*			
ARG 1677	*			*		*		*	*			
ARG 1681		*										
DEB 1140	*							*	*			
DEB 1295	*	*						*	*	*	*	
DEB 1565				*				*		*		
DEB 1566							*					
DEB 1569									*			
DEB 1579										*		
DEB 1810								*				
DEB 1841								*				
DEB 1448								*				
PET 69								*	*			
PET 70								*				
PET 71											*	
PET 72						*			*			
PET 73				*				*	*			
PET 74									*	*	*	
PET 75							*					
PET 722								*	*			
PET 731		*						*		*		
PET 1267	*											
PET 1268									*			
PET 1382									*			
PET 1388												*
PET 1402								*				
PET 1441		*										*
PET 1459									*	*		
PET 1527			*					*				
PET 1648									*			
PET 1649		*								*		
PET 1910								*		*		
PRA 1165								*				
PRA 1326		*							*	*		*
PRA 1333					*		*					
PRA 1334		*		*						*		*
PRA 1335										*		
PRA 1342				*		*		*	*			
PRA 1824								*				
PRA 1827		*										
PRA 1828								*				
NIV 1408						*						
NIV 1413				*								

TAB. 2 DETERMINATION OF RESTORER GENES IN PERENNIAL WILD SUNFLOWER SPECIES

SPECIES	CMS TYPE											
	CMG-1		CMG-2		CMG-3		Indiana-1		CMS-PET-1		ANN-81	
	Full. rest.	Hetero-zygous	Full rest.	Hetero-zygous	Full rest.	Hetero-zygous	Full rest.	Hetero-zygous	Full rest.	Hetero-zygous	Full rest.	Hetero-zygous
DEB-B		*		*				*				
DIV 830					*			*				
DIV 1885		*.										
GIG 52												*
GIG 53		+										
gig 53								*	*			
GIG 78				*								
GIG 1889		*		*				*				
GIG 1896								*				
GIG 1897												
GRO 55								*	*			
GRO 56	*			*			*					
GRO 1624		*			*							
GRO 1689		*						*				
GRO 1690		*						*				
GLA 1604								*				
HIR 1536		*							*			
HIR 1537		*										
LAE 1618	*							*	*			
LAE 1619									*			
LAE 1620								*				
LAE 1871				*								
MAX							*					
MAX 15								*				
MAX 31								*				
MAX 32				*								
MAX 33		*										
MAX 33-001		*								*		
MAX 35						*	*					
MAX 37								*				
MAX 39					*							
MAX 40	*							*				
MAX 41									*			
MAX 42							*					
MAX 43					*							
MOL 230- F							*	*				
MOL 285- F		*										
MOL 1530								*				
MOL 1629					*		*					
NUT 239 F					*							
NUT 292 F		*						*				
NUT 1517									*			
OCC 231 F	*							*				
OCC 389		*										
OCC 393								*				
RES 1545	*							*	*	*		
RES 1597								*				
RIG 47		*						*				
RIG 707		*										
RIG 1640		*										
RIG 1693	*											
RIG 72272			*									
SMI 1603								*				
STR 1886	*											
STR 1922								*				
STR 1926								*				
STR 1953		*						*				
TUB	*	*					*	*	*			
TUB NS-2		*						*				
TUB 6						*						
TUB 7								*				
TUB 9								*				
TUB 13							*	*				
TUB 14												*
TUB 15								*				
TUB 24								*	*			
TUB 26							*					
TUB 1503									*			
TUB 1700								*				
TUB 27										*		