

NUCLEAR VIGOR RESTORATION GENES IN CULTIVATED SUNFLOWER THAT RESTORE THE VIGOR REDUCING CYTOPLASMIC EFFECTS OF PERENNIAL *HELIANTHUS* SPECIES

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Introduction

Plants with pale yellow leaves and reduced vigor were observed in backcross progenies of inbred line HA89 in the cytoplasm of perennial *Helianthus* species *H. mollis*, *H. maximiliani*, *H. grosseserratus*, *H. divaricatus*, and *H. angustifolius* (Jan, 1992). The reduced vigor progenies were not observed when HA89 was substituted into the cytoplasm of annual species, *H. niveus*, *H. praecox*, *H. anomalus*, and *H. neglectus*. The cytoplasmic nature of these effects was confirmed by the occurrence of all-normal progenies after crossing HA89 with pollen from reduced-vigor plants. Segregation ratios of one normal (N) to one reduced-vigor (RV) plant in testcrosses and 3 N to 1 RV following self-pollination of heterozygous normal plants, respectively, suggested a single dominant gene control of vigor restoration.

A high frequency of vigor restoration genes was later found among cultivated sunflower lines (Jan and Russo, 2000). Reduced-vigor plants of *H. mollis* x HA89⁸ (vv) were grown in the greenhouse in 1998, and pollinated with 14 cultivated sunflower lines representing diverse genetic backgrounds. Progeny evaluation suggested 11 of the 14 lines possess a dominant vigor restoration gene (VV). This overwhelming presence of vigor restoration genes in cultivated lines suggests a selective advantage of the VV gene. Extensive use of *H. tuberosus* in early sunflower breeding programs might explain the presence of *H. tuberosus* cytoplasm and a single VV gene in most cultivated sunflower.

For further confirmation, experiments were conducted examining the allelic relationship of VV genes among six selected cultivated lines homozygous for the VV genes, and to determine if those lines are in the vigor reducing cytoplasm of perennial *Helianthus* spp.

Materials and Methods

A half diallel cross combination was made among HA271, HA234, VNIIMK, Armavir, Issanka, and HA821, all homozygous for a vigor restoration gene. Testcrosses were made by pollinating the 15 F₁s onto the vigor-reduced cmsRIGX plants in a HA89 background. The use of the cms and RV cmsRIGX x HA89⁵ plants as female parents eliminated accidental selfing during emasculation and increased the accuracy of our experiment. In the second test, the 11 cultivated

lines homogenous or with high frequency of vigor restoration genes in our previous report (Jan and Ruso, 2000) were emasculated and pollinated with HA89 (vv) pollen. The all normal F₁s were grown in the greenhouse, and the F₂ progenies were evaluated for segregation of normal and reduced-vigor plants.

Results and Discussion

The F₁ progenies of the half-diallel crosses among the six cultivated lines were all normal. The testcross progenies of the half-diallel crossed F₁s onto the RV cmsRIG1 were all normal, except the combination of VNIIMK x Armavir, where a segregation of one normal and one reduced vigor plants was observed (Table 1). This indicated that all the six lines possess the same VV gene which was likely derived from *H. tuberosus* by early sunflower breeders in the former Soviet Union. The 1 N to 1 RV segregation in testcross using VNIIMK x Armavir pollen could be due to a heterozygous F₁ resulting from a rare heterozygous parent.

Progenies of the 11 lines, HA271, HA234, VNIIMK, Armavir, Issanka, HA821, RHA296, Peredovik, Smena, P21-VR1, Issanka, and Hopi Dye crossed with HA89 were all normal. With over 400 F₂ progenies, 40 F₂ progenies for each cross, there was not a single reduced vigor plant. This clearly suggests the absence of perennial species cytoplasm in those lines.

The high frequency of VV gene in lines without obvious selective advantage was unclear. Since *H. tuberosus* was used extensively for the improvement of cultivated sunflower for disease resistance, as well as broomrape resistance, it is likely that the VV gene is tightly linked with genes controlling desirable agronomic traits and was simultaneously selected and maintained in those lines. Our next project will be to map the VV gene onto our RFLP map. As more sunflower genes are mapped, the existence of the V gene in so many cultivated lines may eventually be explained. In addition, because of the abundance of VV genes in cultivated germplasm lines, utilization of perennial species cytoplasm in sunflower breeding should not be especially difficult.

References

- Jan, C. C. 1992. Cytoplasmic-nuclear gene interaction for plant vigor in *Helianthus* species. Crop Sci. 32:320-323.
- Jan, C. C. and J. Ruso. 2000. Vigor reducing cytoplasm of perennial *Helianthus* species and their nuclear vigor restoration genes in cultivated lines. Proc. 22nd Sunflower Research Workshop. P. 51-53.

Table 1. Segregation of normal and reduced-vigor testcross progenies of F₁'s from the six parent half-diallel cross pollinated onto reduced-vigor cmsRIGX..

♀ \ ♂	HA271	HA234	VNIIMK	Armavir	Issanka
HA234	40:0				
VNIIMK	40:0	39:0			
Armavir	40:0	40:0	11:11		
Issanka	40:0	40:0	34:0	40:0	
HA821	39:0	40:0	39:0	40:0	40:0