Cytoplasmic Male Sterility in Rubber Dandelion: A Prerequisite to Develop Hybrids

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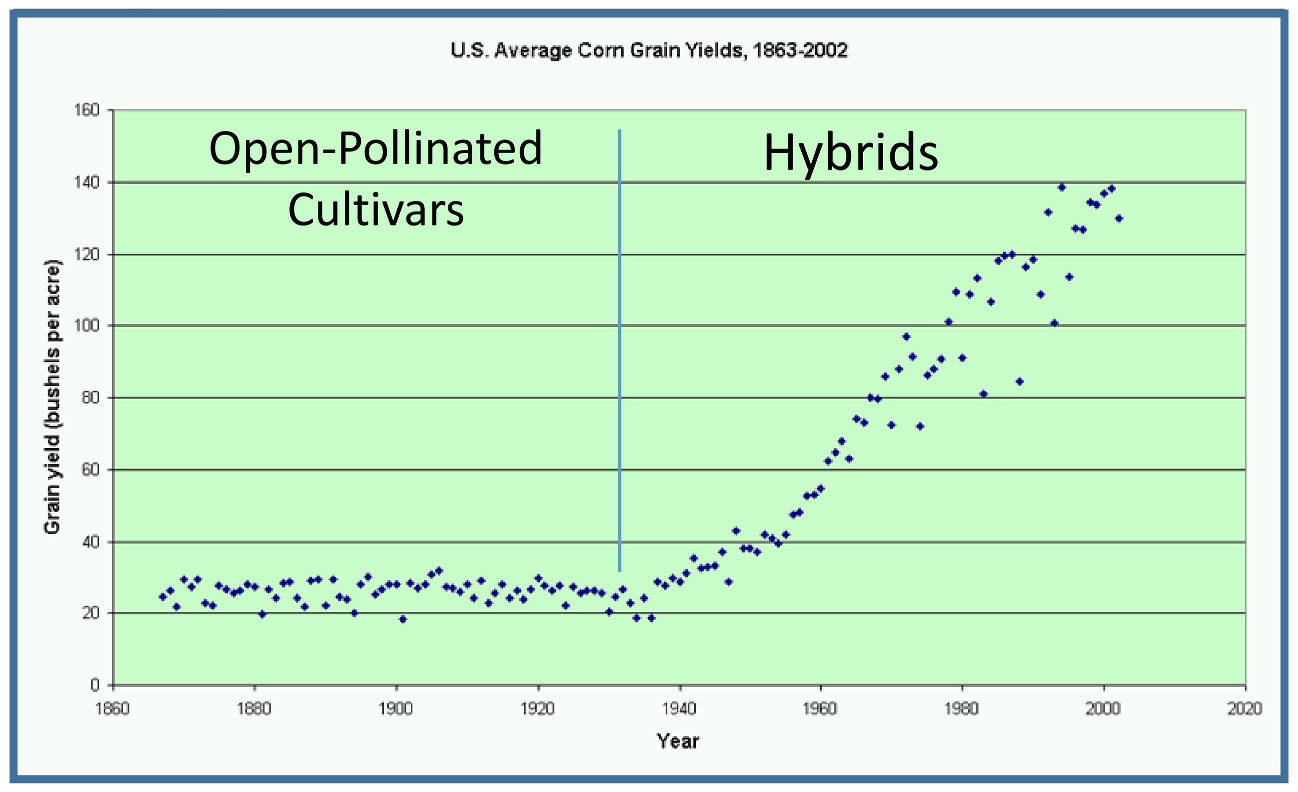
Abstract

The production of rubber dandelion (*Taraxacum kok-saghyz*, TK) hybrids could be advantageous for crop domestication and cultivar development. Identification of a mechanism to facilitate outcrossing between lines, such as cytoplasmic male sterility (CMS), is necessary to produce F1 hybrid seed. A male sterile mutant was identified and a genetic study conducted to determine inheritance. Through the analysis of F1, F2, F3 and backcross (BC) generations, CMS was discovered. Sterility could be restored to fertility by a dominant nuclear *Restorer of Fertility* (*Rf*) allele.

Introduction

- TK is a cross-pollinating, self-incompatible crop and genetics advances to improve populations for rubber and other traits can be made through recurrent selection.
- The development of hybrids can offer significant yield advancements compared to population improvement as demonstrated with corn (Figure 1), although some of the observed increase is attributed to cultural practices. Hybrids can also enhance uniformity which may be critical for improving germination in a cultivar.
- To develop TK hybrids, CMS to promote outcrossing, and self-compatibility mutants to allow selfing and inbred line development, are important.
- Male sterile mutants (Figure 2) were identified and analyzed genetically to determine if they could be useful for hybrids.

Figure 1. Improvements in corn yields with the introduction of hybrids.



http://passel.unl.edu/

Figure 2. Male fertile (left), partial male sterile (middle) and male sterile (right) TK.

Methods

- Crosses were made among plants to generate F1, F2, F3 and BC generations.
- For each observed plant, up to 10 flower heads were phenotyped.
- Plants were categorized as male sterile, partial male sterile, or fertile (Figure 2).
- Chi-square analyses were conducted for predicted segregation ratios of fertile: sterile, where male sterile and partial male sterile types were grouped as one phenotypic class.

Results

- Reciprocal differences in the F1 generation were observed in two crosses between fertile plants (all fertile vs. 1 fertile: 1 sterile) (Figure 3).
- The results could be modeled based on the discovery of CMS interacting with a dominant nuclear *Restorer of fertility* (*Rf*) allele (Figure 3).
  - (S)=sterility inducing cytoplasm-maternally inherited
  - (F)=fertility inducing cytoplasm-maternally inherited
  - (S)*rfrf*=sterile
  - (S)*RfRf* or (S)*Rfrf* =fertile
  - (F)*rfrf*, (F)*Rfrf*, (F)*RfRf* =fertile
- The model is supported by F2, F3 and BC1 data (Table 1)

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Figure 3. Reciprocal differences in fertile x fertile TK crosses and proposed genetic model.

Fertile 1 ♀ X Fertile 2 ♂ = All fertile
Fertile 2 ♀ X Fertile 1 ♂ = 1 fertile : 1 sterile

(F)*rfrf* x (S)*Rfrf* = (F)*Rfrf* [fertile] : (F)*rfrf* [fertile]
(S)*Rfrf* x (F)*rfrf* = (S)*Rfrf* [fertile] : (S)*rfrf* [sterile]

Table 1. Genetic models derived from 70 TK crosses in the F2, F3 and BC1 generations. (F=fertile, S=sterile)

Parents	Parental Genotypes	Progeny Genotypes	Observed (F: S)
S x F	(S)*rfrf* x (F)*rfrf*	(S)*rfrf*	0:1
S x F	(S)*rfrf* x (S)*Rfrf*	1 (S)*Rfrf*: 1 (S)*rfrf*	1:1
S x F	(S)*rfrf* x (F)*Rfrf*	1 (S)*Rfrf*: 1 (S)*rfrf*	1:1
F x F	(S)*Rfrf* x (S)*Rfrf*	1 (S)*RfRf*: 2 (S)*Rfrf*: 1 (S)*rfrf*	3:1
F x F	(S)*Rfrf* x (F)*rfrf*	1 (S)*Rfrf*: 1 (S)*rfrf*	1:1
F x F	(F)*rfrf* x (S)*Rfrf*	1 (F)*Rfrf*: 1 (F)*rfrf*	1:0
F x F	(S)*Rfrf* x (F)*Rfrf*	1 (S)*RfRf*: 2 (S)*Rfrf*: 1(S)*rfrf*	3:1
F x F	(F)*Rfrf* x (S)*Rfrf*	1 (F)*RfRf*: 2 (F)*Rfrf*: 1 (F)*rfrf*	1:0

Conclusions

- CMS was discovered in TK.
- Sterility can be restored to fertility with a dominant nuclear *Restorer of fertility* (*Rf*) allele.
- These new genetic resources could be useful to develop hybrid TK (Figure 4).
- Self-compatibility mutants, which will allow self-pollination, are also required to initiate hybrid TK breeding.

Figure 4. Hybrid production system using CMS.

G101 and G102 = different inbred lines, nuclear genotypes
S= sterility inducing cytoplasmic factor
F=fertility inducing cytoplasmic factor
Rf/rf= nuclear *Restorer of fertility* locus