Skoltech

Skolkovo Institute of Science and Technology

Scientific Training Center in Plant Biotechnologies – Modern Plant Breeding

Regular level

BREEDING IS DRIVEN BY PLANT REPRODUCTION SYSTEMS

Case study #1. Self-incompatibility in white clover.

A number of self-incompatibility alleles (S1, S2, S3, S4) are known in clover. In this case, there cannot be fertilization if the allele carried by the male gamete is identical to one of the style alleles.

1. *What genotypic relationships are expected in the embryos and seed endosperms of subsequent crosses?*

	Parent Style	*Pollen Parent*
(a)	*S1S4*	*S3S4*
(b)	*S1S2*	*S1S2*
(c)	*S1S3*	*S2S4*
(d)	*S1S2*	*S3S4*

2. *If all the F1 progeny of cross (c) are pollinated only by plants of genotype S2S3, what genotypic proportions are expected in F2?*

3. If the F1 offspring of cross (d) are crossed with each other:
   a. *Which genotypes are expected in F2?*
   b. *Which combinations produce 4 genotypes in F2 and which produce only 2?*
   c. *Among the combinations producing 4 genotypes, are there any whose segregation is identical to that of the initial cross?*

4. *If at least one plant of each genotype has been found in F1 (without yet being able to assign each its exact genotype), how can you choose only 3 F1xF1 combinations with the assurance of having at least one F2 with 4 genotypes?*

5. The progeny of the initial cross is composed in F1 of 10 plants designated by a, b, c,…,j. To determine their genotype, a few crosses were made between these plants taken 2 by 2. The result of these crosses is presented in Table 1.
   Classify the 10 plants into 4 self-incompatibility groups.

6. We analyzed the progeny of the crosses ixc, ixh and ixb which still each consist of 10 plants designated by a, b, c,…,j, by carrying out a few F2 xF2 crosses between these plants taken 2 by 2. The results of these crosses are presented in Tables 2, 3 and 4.
   Classify plants by groups of self-incompatibility in each case.
   Which of the 3 F1 x F1 crosses considered segregate into 2 and 4 incompatibility groups?

7. By arbitrarily assigning the S1S3 genotype to the F1 plant called a:
   What is the genotype of plant h?
   Are genotypes c and b defined?

8. *What crosses would you make then to determine with the minimum of effort, the genotype of all the plants of the F1 population?*

Table 1. F1 x F1

	a	b	c	d	e	f	g	h	i	j
a		+		0	+					+
b			+			+	0	+	+	+
c					0		+	+	+	0
d					+	+	+		0	
e							+	+	+	0
f								+		
g								+		
h									+	
i										
j										

Table 2.ixc

	a	b	c	d	e	f	g	h	i	j
a			+	0	0					0
b					0	+	+			
c						0	0	+		
d							+		+	
e								0	+	
f									0	+
g									0	
h									+	
i										
j										

Table 3.ixh

	a	b	c	d	e	f	g	h	i	j
a		+			+	+				
b			0	+	+			0		+
c								0	+	+
d						0			+	+
e										0
f								+		
g								0		
h										+
i										+
j										

Table 4.ixb

	a	b	c	d	e	f	g	h	i	j
a		0					0		+	
b					+				+	+
c					+		0	0		+
d					+	0		0		
e						+	+			0
f										
g									+	
h									+	+
i										0
j										

0 = Incompatible + = Compatible

Case study #2. Nuclear male sterility in maize.

In monoecious maize, a recessive allele called 'tassel-seed' (ts) produces, only in the homozygous state, ovules instead of a stamen inflorescence (tassel). There is no pollen production. Thus, individuals of the ts/ts genotype are reduced to a single sex, that of the female.

On another chromosome, the recessive allele called 'silkness' (sk) produces spikes without pistils (silks) in the homozygous state. Without pistils, the ears cannot produce seeds and sk/sk individuals are reduced to male functions (pollen production). The recessive allele for ts is epistatic to the sk locus.

1. What are the genotypes inducing the [Monoecious wild-type], [male-sterile female], [female-sterile male] phenotypes?

2. What is the sex ratio expected in F1 and F2 from a cross between ts/ts, sk+/sk+ (female) x ts+/ts+, sk/sk (male)?

3. How could the genes for ts and sk be used to establish male and female (dioecious) plants which continued generation after generation to produce a ratio of 1 male: 1 female?

Case study #3. (Nucleo-)Cytoplasmic Male Sterility in Sunflower

A breeder wants to create a new improved F1 hybrid variety of sunflower (*Helianthus annuus* L.) resistant to *Phomopsis* and making use of Cytoplasmic Male Sterility. The characteristics of the available germplasm to do so is as follows:

The sunflower US.123 inbred line is resistant to Phomopsis while IC.12 inbred line is susceptible to the pathogenic fungus but presents cytoplasmic male sterility. These two lines are not productive and do not have interesting agronomical traits.

In contrary, experimental results show the existence of heterosis in yield in the F1 progeny derived from the cross between 2 other productive lines (female CS.06 and male CS.182). These two lines are male fertile and susceptible to Phomopsis.

Crosses were made between US.123 x CS.06 on the one hand, and between IC.12 x CS.182 on the other hand. In the first cross (i.e. US.123 x CS.06), all F1 plants are resistant and male fertile. The following segregation was obtained in the F2 progeny:

Resistant, male fertile 136

Resistant, male sterile 43

Susceptible, male fertile 39

Susceptible, male sterile 14

In the F1 population of the second cross (i.e. IC.12 x CS.182), all the plants are male sterile and susceptible to Phomopsis and in F1xUS.123 all the plants are male fertile and resistant to Phomopsis.

1. Determine the genetic formula of each of the four lines for the traits studied.

2. Present the program for the creation of the Phomopsis resistant F1 hybrid (CS.06xCS.182) by nucleo-cytoplasmic male sterility, using the other two non-productive lines as a source of sterility (IC.12) and fertility restoration (US.123).

3. Which method(s) can be implemented to facilitate and accelerate the breeding program?