Pedigree Naming Systems and Symbols

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Introduction

The continent of Africa with about 283 agro-ecological zones produces a diversity of crops including cereal, pulse, oilseed, root, and tuber species. Although most crops are grown for sustenance, there is tremendous potential for these crops to be sold for profit in local markets and for export, thereby generating economic advantages for farmers and countries. Soybean has been classified as both a pulse and oilseed crop for its use as a source of protein and oil.

African countries contribute roughly one quarter of the world production of root and tuber crops. Bananas (especially cooking bananas) are an extremely important crop in East Africa. For example, in Uganda, bananas are the largest single source of calories for the country.

Objectives

- Provide an overview of the “F” and “S” symbols used to designate generations of selfing or sib-mating.
- Describe how breeding lines are designated by “F#:#” or “S#:#” according to the generation that they were derived.
- Demonstrate pedigree writing.
- Demonstrate how selection history is recorded using a Breeder’s Cross Identification (BCID) designation.

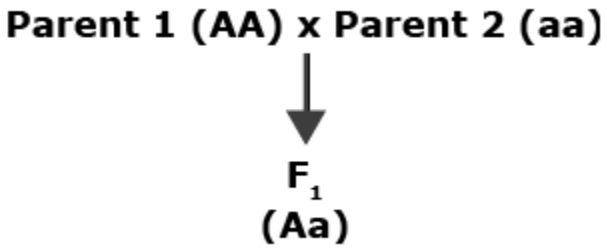
Using F# and S#

Symbology

A. Using "$F_{\#}$" and "$S_{\#}$" to designate the number of generations of selfing or sib-mating:

In plant breeding, the 'F' symbol is used to denote the filial (i.e., family) generation of offspring following a cross between two or more parents. The subscript (#) represents the specific generation ($F_{\#}$). F_1 is the first generation following a cross and subsequent generations are designated F_2, F_3, F_4, etc., based on the number of generations the offspring are self-pollinated or sib-pollinated (i.e., pollinated by a sibling plant in the same progeny row). Pollination can occur naturally or artificially if it is imposed by the breeder. If both of the parents of a cross are homozygous then the F_1 offspring will be homogeneous (i.e., all plants will be uniform and genetically the same) and heterozygous at individual loci. If either or both of the parents are heterozygous then the F_1 offspring will be heterogeneous (non-uniform). In a complex cross involving more than two parents, even if the parents are homogeneous), the F_1 generation will be heterogeneous and heterozygous.

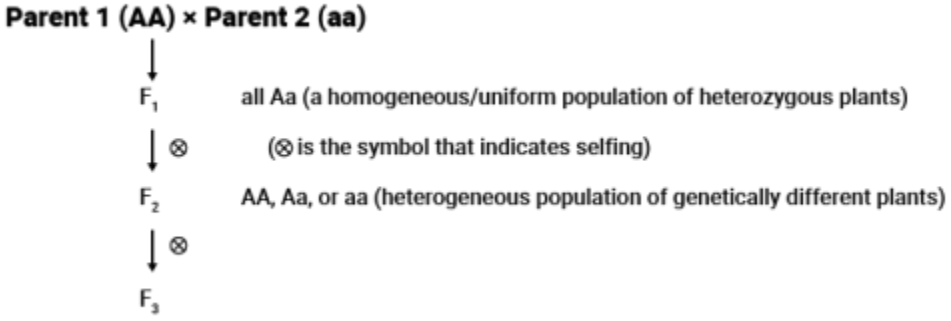
Single Gene Example With Two Homozygous Parents



In the example above, both parents were developed by breeder after undergoing several generations of selfing so that they are homozygous at all loci. The cross between these two unrelated parents produces F_1 progeny that are all uniformly heterozygous (Aa), and F_1 progeny population (all F_1 from this cross) will be homogeneous since each F_1 will be 'Aa' type at this locus.

Self-Pollination

When an F_1 plant is self-pollinated or when two F_1 plants are crossed with each other, F_2 seed is produced. If the parents were homozygous then the F_2 generation is the first generation when the offspring are heterogeneous (i.e., segregating for different parental alleles). The F_2 generation is typically the generation when selection for simple traits begins. Self-pollination of F_2 plants produces F_3 plants, self-pollination of F_3 plants produces F_4 plants, and so on.



Cross-Pollinated Species

In cross-pollinated species, '$S_{\#}$' is used instead of '$F_{\#}$'. The symbol S_0 can be used to describe the progeny from a single cross between two homozygous parents as either:

1. Similar to F_1 (in self-pollinated) which indicates that the plant was not derived from self-pollination or
2. Similar to F_2 (in self-pollinated) which indicates that the population is formed by random mating and is therefore heterogeneous and heterozygous

Therefore, it is important that the breeder clearly describes what he/she is referring to in a particular situation and then be consistent in usage.

Using Fx:y and Sx:y

Breeding Lines

B. Using "$F_{x:y}$" or "$S_{x:y}$" to describe breeding lines according to the generation they were derived:

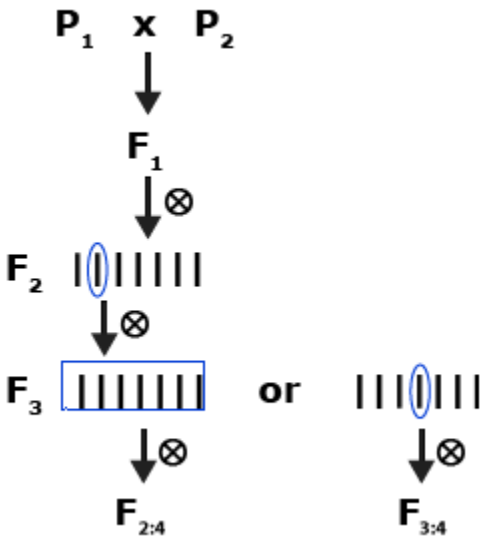
Breeding lines (or genotypes) are derived from individual plants at various generations. An $F_{2:4}$ line refers to an F_4 line that was derived from a single F_2 plant. The F_2 plant was selfed to produce F_3 seeds, which were then grown in a single F_3 progeny row, self-pollinated, and then harvested as a F_4 bulk of many or all of the F_3 plants in this row. Based on this scheme each individual F_2 plant gives rise to a genetically distinct $F_{2:4}$ line. These lines are also described as "F_2-derived lines in the F_4 generation", or simply "F_2-derived F_4 lines".

Summary

An $F_{3:4}$ line refers to an F_4 line (or progeny row) created from a single F_3 plant growing in an F_3 progeny row that was produced from the seed of a self pollinated single F_2 plant. An individual plant was selected from an F_3 row to produce F_4 seed and this seed when grown represents an $F_{3:4}$ line. These are also described as "F_3-derived lines in the F_4 generation", or simply "F_3-derived F_4 lines". The difference from $F_{2:4}$ lines is because the first subscript designates the generation of the last individual-plant selection.

To summarize:

$F_{x:y}$ or $S_{x:y}$, describes 'x' as the generation where single plant was harvested separately to give rise to the derived line, and y represents the current generation of inbreeding of the plants within this derived line.



Writing a Standard Pedigree

Symbology

C. Example of writing a standard pedigree:

Each organization follows a different standardized system for recording pedigrees. In this section, we will describe the system used by wheat breeders at CIMMYT (CGIAR institute) [Information provided with permission from Dr. K. Ammar, Durum wheat breeder]. Depending on the crop you work on and where you are employed you may use a modified system.

The female parent is designated by listing it first (starting from the left) followed by the male parent (on the right). For example, A is the female parent and B is the male parent in an (A x B) cross. An (A x B) cross can also be written as A/B.

If an F_1 (A/B) plant is pollinated with parent C, and the F_1 is used as the female and C as the male, the resulting three-way cross would be designated as A/B//C. Subsequent crosses with parental materials D, E, F, and G used sequentially (all as males) are indicated using a number to record the cross order in the following way: A/B//C /3/D/4/E/5/F/6/G.

Example

If the example above is changed to use D & F as female parents, with E and G remaining as males, the cross would be recorded as follows:

- Step 1: A/B is the first cross,
- Step 2: A/B//C is the second cross, where A/B is the female.
- Step 3: **D/3**/A/B//C is the third cross, with D as female, and A/B//C as male.
- Step 4: D/3/A/B//C/**4/E**, with E as male, and the 4-parent cross as the female. NOTE: bold and underline text is for information and instructional purpose only. In writing a pedigree, you will not have to bold text. One will simply write the pedigree as D/3/A/B//C/4/E

The inclusion of “F/5” as the female and 6/G as a male completes the pattern.

Backcross Pedigree

In multiple backcrosses, the sequence of these letters from left to right corresponds to the sequence in which the backcrosses are made. Backcross pedigrees include an asterisk (*) and a number indicating the dosage of the recurrent parent. The asterisk and the number are placed next to the crossing symbol (/) that divides the recurrent and donor parents. The following are examples of pedigree formats involving backcrosses:

- A is the recurrent parent: A*2/B of the initial cross and has been used as a parent two times. Therefore, A*2/B indicates one backcross or a BC_1 cross.
- B is the recurrent parent: A/3*B, and has been used as a parent three times. Therefore, A/3*B indicates a BC_2 cross.

A*2/B is therefore A//A/B and indicates that A was used as a female in both F_1 and BC_1.

A/3*B could be B/3/A/B//B and indicates that A was used as a female, F_1 was then used as female, and BC_1 was used as male.
A/3*B could be A/B//B/3/B and indicates that A was used as a female, F_1 was then used as female, and BC_1 was used as a female.

The F#: derived symbols as previously described for regular crosses will follow the $BC_{\#}$ designation. For example, $BC_1F_{2:4}$ or $BC_2F_{2:4}$.

Identity Number

Assigning an Identity Number to Each Cross or Backcross

Every cross should receive a unique ID number that will allow everyone in the breeding group to recognize the year the cross was made (e.g., 2014), a cross number (e.g., 1001), and perhaps the target purpose of the cross (e.g., HO for high-oil, or abbreviation for another specific trait or market segment).

Using BCID

Recording Selection History

D. Recording selection history using a Breeder's Cross IDentification (BCID) designation:

Every F_1 plant, segregating line, or advanced line in a program is assigned a Breeders' Cross ID (BCID) and a selection history. This selection history records the process of selection, which describes where and how the initial cross was made and where and how subsequent selection steps occurred for each generation of selection.

Example

An example of this system is provided below (using CIMMYT's wheat breeding program).

Each BCID begins with a letter designation for the origin of the cross (e.g., CM = crusa Mexicana; Spanish for 'Mexican cross'). This is followed by an indication of the kind of cross (e.g., BW = bread wheat x winter wheat, SS = spring x spring wheat; SW = spring x winter wheat), an abbreviation of the year when the cross was made (e.g., 00 = 2000), an abbreviation of the location where the cross was made (e.g., Y = Yaqui Valley), and finally a sequential number representing the order in which that cross was made within the crossing cycle (e.g., 0124). The table below shows the letter codes used to indicate the locations in Mexico where crosses were made and the different environmental conditions where CIMMYT breeders carry out selection in wheat.

Table 1

Code	**Description of Location and/or Environmental Condition**
B	El Batan
M	Toluca ("M"stands for the State of Mexico)
Y	Cd. Obregon full irrigation (Cd. = Cuidad = city; "Y" stands for Yaqui valley region in Mexico)
KBY	Dc. Obregon Karnal bunt
HY	Cd. Obregon Heat (heat, late planting)
SY	Cd. Obregon Semi-arid (reduced irrigation)
PR	Poza Rica
PZ	Patzcuaro
SJ	Sierra de Jalisco (El Tigre)
AL	Selection for tolerance to low PH and aluminum toxicity in laboratory test (El Batan)
YDB	Selection for BYDV tolerance in El Batan (BDV = barley yellow dwarf virus)
Note: this is a partial list to demonstrate the usage of abbreviation. More abbreviations are used to describe locations or nurseries.	

Location Codes

Location codes for other countries were determined by the cooperators/breeders in those countries to ensure that everyone was aware and compliant. Hypothetical examples of BCIDs and selection histories are presented below.

Table 2 Examples of BCIDs and selection histories for a simple cross using the pedigree method, the modified pedigree/bulk method, and the selected bulk method.

Example #	Type of cross	Breeder's Cross ID (BCID)	Selection history (by generation)						
			F_1	F_2	F_3	F_4	F_5	F_6	
1	A/B	CMBW08Y0199	-	35Y	15M	7Y	5M	12Y	
2	A/B	CMBW08Y0124	-	81Y	010M	010Y	010M	15Y	
3	A/B	CMSS07Y051	-	030Y	030M	030Y	53Y	0M	

Example 1: BCID = CMBW08Y0199, a single cross was made in Mexico (“CM”) in 2008 between a spring and winter wheat at location ‘Y’ and this was cross#0199 that year. The pedigree method of selection was followed for the development of genotype. The selection history for this example indicates that in the F_2, the 35^{th} plant was selected at location “Y”, and in the F_3 generation this was the 15^{th} plant selected at location “M”, etc. Finally, in the F_7 the “0M” indicates that a single plot was grown at location “M” and harvested in bulk (i.e., all plants in the plot were harvested into one bag or packet). This created the genotype CMBW08Y0199-35Y-15M-7Y-5M-12Y-0M.

Examples 2 and 3

Example 2: BCID = CMBW08Y0124, a single cross was made in Mexico ("CM") in 2008 at location "Y", with 0124 designating that this cross was number 0124 in the series of crosses made at that location and year. The selection history reflects that a modified pedigree/bulk selection method was used. In the F_2 the "81Y" indicates that this genotype was the 81st individual plant among those selected at location "Y." The F_3 designation of "010M" indicates that 10 plants were selected and harvested in bulk from the F_3 progeny row grown at location "M." Seed from the bulked F_3 progeny row was planted at location "Y" in the F_4 and 10 plants were selected and harvested in bulk. Similar scheme was used in F_5. In the F_6 a single plant was selected from this genotype (15th plant) at location "Y" and constituted the seed for the next generation. In the F_7 (or more appropriately, $F_{6:7}$) all plants in the progeny row at location "M" were harvested in bulk, as shown by the designation "0M". This created the genotype CMBW08Y0124-81Y-010M-010Y-010M-15Y-0M.

Example 3: BCID = CMSS07Y051, which describes that a single cross was made in Mexico ("CM") in 2007 at location "Y", with 051 designating that this cross was number 051 in the series of crosses made at that location and year. The cross was of type "SS", spring wheat x spring wheat. The selection history indicates four generations (F_2-F_4) of selection in which 30 plants were bulked from the progeny row (or plot) for each season at either the "M" or "Y" locations. In the F_5 generation the genotype selected was the 53rd plant from the bulk plot at the "Y" location. In the F_6 a complete plot bulk was harvested at location "M". This lead to the creation of the genotype CMSS07Y051-030Y-030M-030Y-53Y-0M.

Additional Notes

After the BCID, the selection history is presented in which the numbers identify the number of individual plant(s) selected and the letter indicates the location where selection took place and/or under what specific conditions selection was conducted.

The zero-letter combinations (e.g., 0Y, 0M, etc.) are reserved for populations harvested in bulk during that generation (i.e., the entire plot was cut and threshed as one unit). A zero followed by a number (e.g., 05…, 010…) and then by a letter indicates that the modified pedigree/bulk selection method was used in which a certain number (e.g., 5 or 10) of selected heads are bulk (0) harvested. The location where the selection was made and, in some cases, the special type of selection performed, is indicated by a letter code.

References

Purdy, L.H., W.Q. Loegering, C.F. Konzak, C.J. Peterson, and R.E. Allan. 1968. A Proposed Standard Method for Illustrating Pedigrees of Small Grain Varieties. Crop Science 8:405-406.

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