CERERE INNOVATION FACTSHEET #9, March 2018 www.cerere2020.eu

This project received funding from the European Union's Horizon 2020 Research and Innovation program under Grant Agreement n° 727848.

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Manual crossings to mix genetic diversity of cereal populations

Manual crossing of autogamous cereals is a blending technique for crop diversity that is readily available to farmers, as it does not require sophisticated equipment (only scissors and forceps).

Definition:

Because wheat is autogamous, plants become genetically static after several generations of self-pollination. In diploid species, plants therefore tend to become homozygous (the two versions of their genes are the same). We can take as an example two plants, one "AA" and the other "aa": when the first self-pollinates, successive generations maintain the same "AA" combination. If we cross the two plants, the first provides an "A" allele and the second an "a". Seeds from the crossing will therefore be heterozygous – "Aa". Wheat self-pollinates in 95% of cases, such that there are few crossings in a given population. To the end of increasing diversity, manual crossing can produce interesting results. This operation consists in castrating a plant which will be the female and giving it pollen of another plant with the male function.

Rationale:

Such manual crossings of autogamous cereals represent a technique that is readily available to farmers, as it does not require sophisticated equipment (only scissors and forceps).
In the context of a selection program, manual crossing is an efficient way of mixing the genetic diversity of populations on a single farm, creating new allele combinations that could not be obtained through self-pollination. These new allele combinations lend new characteristics and behaviors to generations resulting from the crossing, which can later be selected based on the needs and aims of farmers.

Protocol:

Figure 1 shows a screenshot of an information card for crossing soft wheat varieties that was created by the Moulon INRA and the Rete Sementi Contadine.

- Selection of the spike to castrate: it should not be protruding too much from the upper part of the sheath.
- Remove the sterile spikelets from the base of the spike.
- Remove the central florets of all the spikelets.
- Cut the upper part of the spike, where the sterile spikelets are found.
- Cut the upper part of the spikelets.
- Remove the three anthers of each floret (there are three anthers per floret and two florets, so six anthers are to be removed from every spikelet).
- Place a crossing bag around the emasculated spike to protect the stigmas from surrounding pollen; note the date of the castration.
- Wait four or five days until the female spike is receptive and the stigmas are well feathered.
- Choice of the male spike: its flowering (protruding anthers) must be 1 cm in length on the spike.
- Place the male spike over the female, shake the crossing bag and close it, leaving the male in. The male spike can be removed one week following the crossing. (N.B.: the crossing bag can be left on until harvesting).

Limitations:

Not all wheat varieties can be crossed. There are certain limits to performing effective, reproducible crosses, such as differences in the ploidy levels between two populations to be crossed (for example, it is not possible to cross diploid Einkorn wheat with hexaploid soft wheat). Another limitation in performing crossings may be due to too great a difference in maturation times between two populations to be crossed: if the pollen development in the population with the male function is too far out of sync with respect to the stigmas of the population with the female role, the crossing will not be possible.
In addition, when spikes are emasculated, it is possible the anthers are not completely removed from the spikelets. These anthers release pollen which fertilize the stigmas in the spikelets, causing self-pollination. This can take place in successive generations following the crossing: if all plants descending from the crossing are similar to each other but different from the "mother" plant, the crossing was successful; if, though, some (or all) of the plants from the crossing are similar to the "mother" population, this means that there was at least some self-pollination.

Specific cases:

In the participatory selection program of cereals begun in 2006 by the Rete Sementi Contadine ("Farmer Seed Network"), conducted in collaboration with the Moulon branch of INRA, 90 crossings were produced. The parent plants were selected by a farmer who participated in the project, while a research team provided technical support. The new populations descending from the crossings were distributed to a network of 20 farmers in France in 2008 for evaluation and selection. Since then, several farmers who participated in the project have created new crossings. Figure 2 shows a photo of the Japhabelle population (center and right of photo), the result of a crossing, next to the parent populations (left). We can see the parents are bending, while Japhabelle is upright.

References:

Figure 1: S. Jouanne-Pin, N. Galic. Capture de la fiche pratique pour croiser des blés tendres élaborée par l'INRA du Moulon et le Réseau Semences Paysannes. La fiche complète peut être trouvée à l'annexe Q de la thèse de Pierre Rivière [http://ressources.semencespaysannes.org/docs/va_riviere_pierre_15012014.pdf]

Figure 2: I. Goldringer. Population Japhabelle chez Jean-François Berthellot. 2014 / License CC BY NC SA

Additional information:

Rivière, P. 2014. « Méthodologie de la sélection décentralisée et participative : un exemple sur le blé tendre ». Université Paris-Sud, École Doctorale : Sciences du Végétal. PhD thesis. pp. 251 – 255.

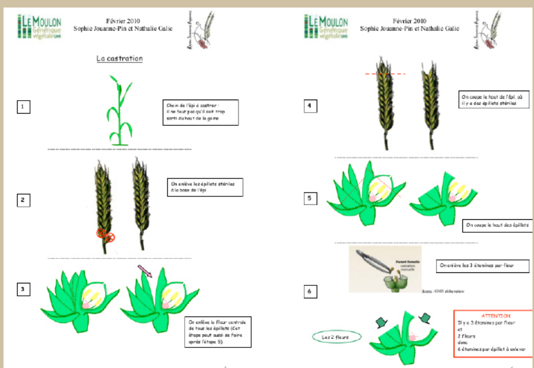

Figure 1

Figure 2