THE USE OF VEGETATIVE REPRODUCTION IN THE BREEDING OF CROSS-FERTILIZING PLANTS

J. HEEMSTRA
Wiersum Seed Company, Groningen; formerly Horticultural Advisory Officer

Received 29 Jan. 1955

1. INTRODUCTION

In recent years vegetative reproduction has been used by many breeders for the improvement of cross-fertilizing plants. S. J. WELLENSIEK (1, 2), in the Netherlands, has drawn attention to the significance of vegetative propagation in the breeding of cross-fertilizing plants. On his advice I have committed my experience to paper, since I used this method nearly forty years ago. I realize that this report will mainly serve a historical interest.

2. HISTORICAL FACTS

In the course of and at the end of the first world-war an urgent need for good seeds arose. Many seeds of unknown origin appeared on the market. Farmers and gardeners with little experience in plant-breeding became interested in seed-growing.

In my function of Government Horticultural Advisory officer, I had already stimulated this interest since 1911 and I attempted to establish a sound basis for this type of seed-growing. My personal activity in experimental plant-breeding, during this period, was favoured by a very agreeable co-operation with growers and especially with the heads of trial-gardens in my district, who were interested in this kind of work.

The general scheme of work was induced by the problem of finding a practical method for the breeding of cross-fertilizing plants in such a way, that the progeny of a variety put on the market would behave according to predicted standards. With this object in view, I have used methods of vegetative reproduction in plant-breeding experiments with sugar beet, rye and cabbage.

3. BREEDING METHOD

The use of vegetative reproduction in conjunction with a breeding method was, above all things, influenced by the universally known genetical facts, such as:

1. The vegetative multiplication of one plant, called a clone, results in a genotype like the original mother-plant.

2. When we have a cross of two plants or of two clones with interpollination and a sufficient production of seeds, we always get, after repeating these crossings, the same $F_1$ generation and this means the same mixture of different genotypes.

3. Every $F_1$ of cross fertilizing plants gives an $F_2$ progeny, which has, in the following generations, the same genetical constitution as the $F_2$, provided that no contamination takes place and that all plants (genotypes) give practically the same number of healthy seeds after complete panmixis.
J. HEEMSTRA

4. NUMBER OF GENOTYPES IN F₁, F₂-Fₙ, OF CROSS-FERTILIZING PLANTS

The F₁-generation from a pair crossing of heterozygous genotypes of cross-fertilizing plants is more uniform than the F₂-generation or succeeding generations and, this also holds when the F₁-generation is compared with a pedigree-progeny.

This is explained when we consider two such parents, if cross-fertilized. We may consider, that these plants, with an unknown genetical structure, may have half of the gene pairs in a homozygous condition and the other half heterozygous. Moreover these gene pairs of both plants are, in comparison with each parent, unequally divided and this means that they are arbitrarily localized as homozygous or heterozygous gene pairs. For any gene pair in both plants, they may be AA or Aa or aa. The possible combinations of distinguishable genotypes after crossing in the F₁, are as follows:

Table 1. The number of distinguishable genotypes:
1st without dominance (AA and Aa distinguishable from the phenotype). Total 32 on 16 combinations of 2 gene pairs. In ratio 2 : 1.
2nd with dominance (in brackets, AA and Aa with the same phenotype). Total 24 on 16 combinations of 2 gene pairs. In ratio 1½ : 1

<table>
<thead>
<tr>
<th>² gam. of</th>
<th>AA</th>
<th>Aa</th>
<th>Aa</th>
<th>aa</th>
</tr>
</thead>
<tbody>
<tr>
<td>AA</td>
<td>1 (1)</td>
<td>2 (1)</td>
<td>2 (1)</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Aa</td>
<td>2 (1)</td>
<td>3 (2)</td>
<td>3 (2)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>Aa</td>
<td>2 (1)</td>
<td>3 (2)</td>
<td>3 (2)</td>
<td>2 (2)</td>
</tr>
<tr>
<td>aa</td>
<td>1 (1)</td>
<td>2 (2)</td>
<td>2 (2)</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>

In the F₂ and following generations and also in a pedigree progeny of the same variety (strain), we realize that without any selection and with complete panmixis, these plants are fertilized from both sides (males and females) with equal numbers of A- and a-gametes, B- and b-gametes, and so on. Comparatively it gives the same results in a number of different genotypes as the progeny of Aa-individuals.

After cross-fertilisation we get:

\[(A + a)(A + a) = 1 AA + 2 Aa + 1 aa\]

number of distinguishable genotypes:
1st. without dom. \[1 + 1 = 3\] distinguishable genotypes on 1 comb. of 2 gene pairs.
2nd. with dom. \[1 + 1 = 2\] genotypes on 1 comb.

of 2 gene pairs.

From this it may be concluded that, in crossing an A-plant with a B-plant with equal numbers of homozygous and heterozygous gene pairs in both plants and arbitrarily localized in both parents and with a total of n gene pairs in each plant we get:

\[
\begin{align*}
\text{1st. without dom.} & \quad \frac{2^n}{in F_1} & \quad \frac{3^n}{in F_2-F_n} \\
\text{2nd. with dom.} & \quad \frac{(1\frac{1}{2})^n}{2^n}
\end{align*}
\]

In the above-mentioned explanation we supposed hypothetically, even numbers of