

# A Collaborative Breeding Strategy for Organic Potatoes in the Netherlands

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## Introduction

Average potato yields in Dutch organic farming systems are rather low and variable (12 to 35 tonnes/ha) compared to Dutch conventional farming standards (50-60 tonnes/ha). The main reason for this year-to-year variation in yield is due to the disease known as late blight, caused by the pathogen *Phytophthora infestans*, the timing and severity of infection is unpredictable and very variable. In the last few years late blight has been so devastating in organic potato production that its acreage has decreased by 20%. The ability of the organic farmer's agronomic toolbox to reduce the susceptibility of a potato crop to late blight is limited, certainly under the Dutch climatic conditions. Conventional breeding programs do not generate either a sufficient number nor appropriate types of resistant varieties for organic systems; and a separate breeding program for the limited area of organic potato production is simply not viable. Therefore, all concerned forces have joined together in an umbrella program called *Bioimpuls* for organic potato improvement. Within this program there is a joint breeding project aimed at developing better adapted and late blight resistant varieties. With financial support from the Dutch Government this organic breeding program started in 2008. It is managed through the cooperation of six potato

breeding companies, organic farmers and breeding scientists from the Louis Bolk Institute and Wageningen University.

## Collaborative breeding strategy Structure

The organic breeding program has built on an successful collaborative structure between potato farmers and company breeders that has existed in the Netherlands for more than a hundred years, a set up that is hardly known in other European countries.

In this system each farmer-breeder discusses individually with the company breeder which combinations of traits they consider are desirable and which parent lines should be crossed to have the greatest chance of meeting the breeding goals. In this way the farmer's experience in growing potato varieties and the breeder's experience in heritability of traits are integrated. The company breeder is better equipped to conduct the crossings in the greenhouse and to collect the seeds. The following spring the seedlings are raised by the company breeders and offered to the farmer-breeder to grow on. On average, a farmer-breeder yearly plants 500-1,000 new seedlings, though some can cope with more. Each seed can be the basis of one potential variety. In the first year the seedling is planted and its progeny (4-6 tubers) are then evaluated and selected or discarded.



After the first year, the selected tubers are multiplied vegetatively, ensuring that there is no further segregation and therefore the selection is relatively easy for farmers. Farmer-breeders select for basic agronomic characteristics such as foliage and tuber appearance, length of stolons, tuber size and distribution, adding their own insights and preferences. The selection percentage is individual, but can for instance be 15% in the 1st year (150 out of 1000 clones), 33% (50 out of 150) in the 2nd year, and 0-30% in the 3rd year (0-15 out of 50). The company breeder will proceed with the clones that are selected by the farmer-breeder and will test them on further quantity and quality traits, and might end up with one potential variety that will be sent in for the official trials for variety registration.

**Contract for sharing royalties**

At the start of a collaboration between a breeding company and a farmer-breeder a contract is

signed arranging the legal aspects of the collaboration, such as ownership of the genetic resources and sharing of the royalties. If a farmer-breeder’s selection is successful and ends up as a marketable variety, it will be registered in the name of the farmer-breeder, but the company will represent the variety in the market and will conduct its maintenance. Therefore, the company will collect the royalties and will keep a yearly account of the received royalties based on the volume of seed potatoes sold. The sharing of the royalties is usually on a 50-50% base, depending on the amount of work conducted by each party. The yearly selection effort of the farmer-breeders has contributed to an increase in the number of potato clones selected each year and therefore the chance of success. Thus, this system has, over the past years, achieved great progress in the Dutch potato breeding sector, with about 50% of the released Dutch varieties being a result of this collaborative system.

Year	Activity	Company breeder	Farmer-breeder
0	Choice of parents	x	x
1	Crossing and harvesting seeds	x	
2	Sowing and raising of 1 <sup>st</sup> year seedlings	x	
2 - 4	Visual selection in the clones for basic agronomic characteristics		x
5 - 8	Trials for production, resistances, quality and adaptation	x	
5 - 12	Yearly visit and discussion on progress	x	x
9 - 12	Research for potential market, registration on national variety list, obtaining plant breeder’s rights	x	
13 -15	Market introduction, maintenance, collecting of royalties	x	
13 -	Yearly accounts and sharing of royalties	x	x

**Table 1: Sharing of breeding activities in a collaborative model of potato breeding in the Netherlands.**



## Breeding for organic agriculture

### Training courses

One of the aims of the *Bioimpuls* organic breeding program is to increase the number of farmer-breeders involved. The more farmer-breeders associated with a breeding strategy based on a ‘no cure/no pay’ basis, the more economically feasible the breeding program becomes. Before the start of the project only two of the 160 potato farmer-breeders active in the Netherlands were organic farmers. After 14 years of effort, one of these two farmers was recently successful with the selection of the variety called Bionica, which in 2007 was marketed by the associated breeding company C. Meijer B.V. In spring 2008 and 2009 the first organic breeding courses to introduce the basic principles of potato breeding and selection were organised for interested farmer-breeders. The course gives farmers more insight into the breeding process and helps them realize that such a long-term activity needs commitment, skill and time; and that, therefore, must be given organizational space within their farm management. Currently, a total of eight organic farmer-breeders have joined the organic breeding program where the farmers will be supervised by an experienced potato breeder.

### Pre-breeding

Next to the breeding activities of farmer-breeders, there is also a need for a long-term pre-breeding activity to generate new genetic material, including new sources of late blight resistance by using material that was identified in earlier projects by Wageningen University. Therefore, specific crossings were made, including the introduction of new sources of resistance found in the species *Solanum bulbocastanum*, *S. berthaultii*, and *S. okadae*. It is planned that as much as possible these new sources of resistance should be inte-

grated into a genetical background that includes other required traits for organic potato, such as nitrogen-efficiency, resistance to *Rhizoctonia* and early blight, and early tuber setting and bulking.

Collaboration between central organic (pre-) breeding program and commercial breeding

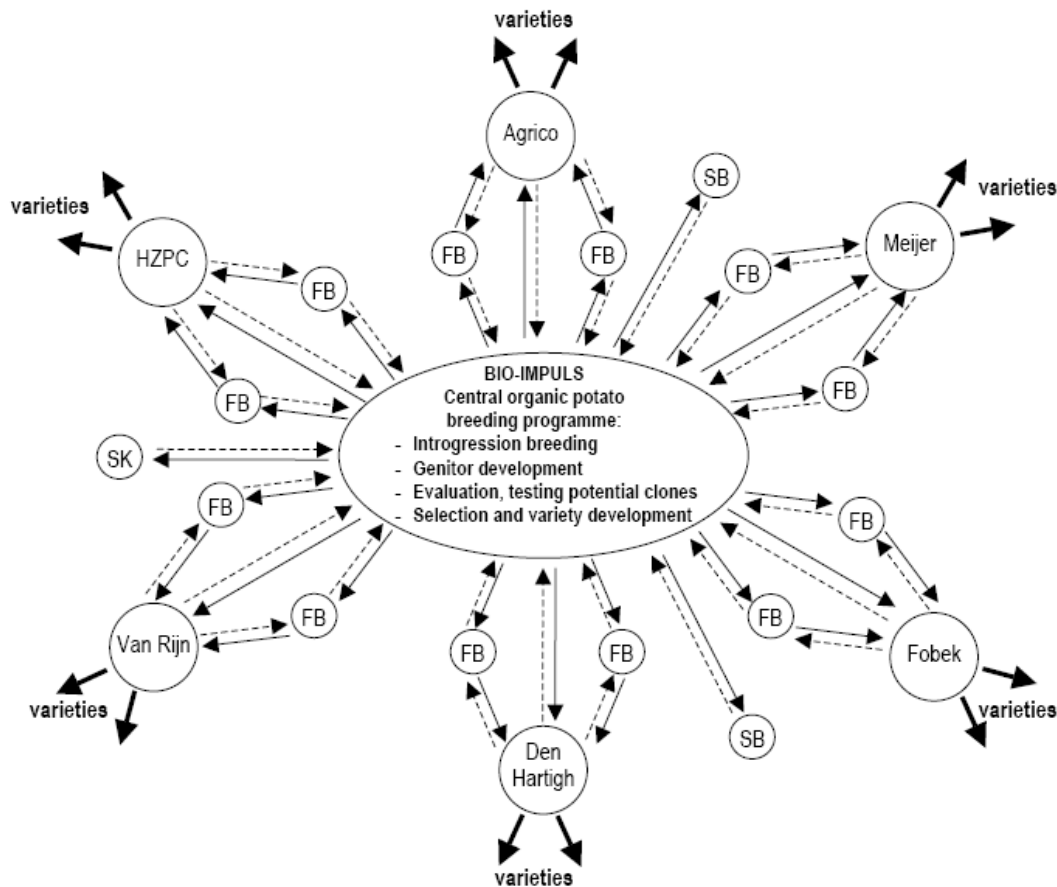
The organic potato breeding program now includes the cooperation of six commercial breeding companies that are already involved in the propagation of organic seed potatoes. The farmer-breeders are all attached to one of these companies. Each year the farmer-breeders receive seedlings from the central organic breeding program, conducted by Louis Bolk Institute and Wageningen University, and/or from their commercial breeding company. The breeding companies can produce crosses with their own selected parents as well as derive new genetical sources from the central organic breeding program. Through a contract between the central breeding program and the involved farmer-breeders and breeding companies, it is agreed that in future



A potato farmer-breeder assessing the first-year clones with Bioimpuls breeding assistants in 2009.

(Photo: Louis Bolk Institute)





**Figure 1. Overview of the collaboration between the central organic potato (pre-)breeding program Bioimpul, the farmer-breeders (FB), some independent small breeders (SB), and named commercial breeding companies in the Netherlands, 2009.**

when varieties derived from plant material from the central breeding program are registered, 10% of the royalties will flow back to the program. This means that the program will be able to partly generate its own income for future breeding activities.

**Future**

An organic breeding program as described in this article can only be successful and economically feasible when the number of organic farmer-breeders increases. It is estimated that at least 20,000 seedlings per year need to be tested for the program to be viable. Potato breeding is a long-term activity and is a continuous search for new resistance sources. The recent release of a new late blight resistant variety shows that with the

efforts of more organic farmer-breeders the selection of a range of varieties suitable for organic potato production in the future is achievable.

However, the resistance traits that will be used in the organic breeding program are based on race-specific *R*-genes. This kind of resistance is assumed to be not durable. Therefore, the project’s program will include pyramiding of two to three genes from different sources in many different combinations. However, in the field one can only see whether a clone is resistant or not, and not whether the resistance is caused by one, two or three genes. In the future, marker assisted breeding using freely accessible markers, will be a necessary instrument to achieve such adequate pyramiding.

