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The BIOEXPLOIT Project

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Abstract The EU Framework 6 Integrated Project BIOEXPLOIT concerns the exploitation of natural plant biodiversity for the pesticide-free production of food. It focuses on the pathogens *Phytophthora infestans*, *Septoria tritici*, *Blumeria graminis*, *Puccinia* spp. and *Fusarium* spp. and on the crops wheat, barley, tomato and potato. The project commenced in October 2005, comprises 45 laboratories in 12 countries, and is carried out by partners from research institutes, universities, private companies and small-medium enterprises. The project has four strategic objectives covered in eight sub-projects. These objectives relate to (i) understanding the molecular components involved in durable disease resistance, (ii) exploring and exploiting the natural biodiversity in disease resistance, (iii) accelerating the introduction of marker-assisted breeding and genetic engineering in the EU plant breeding industry, and (iv) coordinating and integrating resistance breeding research, providing training in new technologies, disseminating the results, and transferring knowledge and technologies to the industry.

Keywords Pathogens · Pesticide-free food production · Plant biodiversity · Potato · *Solanum*

Introduction

The EU Framework 6 Integrated Project BIOEXPLOIT (Exploitation of natural plant biodiversity for the pesticide-free production of food) commenced in October 2005 and comprises 45 laboratories from 12 countries. The Integrated Project is coordinated by Professor Jaap Bakker from Wageningen University, Wageningen, The Netherlands. Approximately 25% of the participants are based in companies or small-medium enterprises (SMEs). The project aims to exploit natural plant diversity

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for the production of pesticide-free food from wheat, barley, potato and tomato crops.

The European Association for Potato Research (EAPR) participates in the part dealing with the dissemination to the potato research community of the results obtained in the project.

Relevance and Overall Objective

In the EU-15, more than 230 million kg pesticides are used per annum to control fungi, insects, nematodes, viruses, and, to a lesser extent, bacteria. About 61% of these chemicals are used for fungal or fungal-like pathogens in major crops such as cereals, potato, fresh fruit, vegetables, sugar beet and vineyards. In arable farming 70% of the fungicides are used to combat fungal and oomycete pathogens in potato and cereals, mainly wheat and barley. The overall objective of this Integrated Project is to provide alternatives for these fungicides in the two main European food crops, wheat and potato, by exploiting natural variations in host plant resistance. This will be accomplished by developing genomics and post-genomics tools to design durable resistance to fungal pathogens by studying the genes and molecular mechanisms, of both the plants and their pathogens, underlying qualitative and quantitative resistance traits. These tools will be used to mobilise the genetic resources of potato and wheat stored in European gene banks and to accelerate ongoing breeding programmes.

The Target Pathogens in BIOEXPLOIT

The main target pathogens in this project are *Phytophthora infestans* in potato and *Septoria tritici*, *Blumeria graminis*, *Puccinia* spp. and *Fusarium* spp. in wheat. Although disease resistance is an important trait in plant breeding, many diseases are still hard to control without the use of pesticides. Considering the risks for human health and the environment, these pesticides are still tolerated because no suitable alternatives are available at present. Although world-wide huge investments have been made to create transgenic plants with various types of resistances, the European plant breeding industry has been confronted with continuous doubts about the commercial future of genetically modified (GM) crops. Due to the public debate on Genetically Modified Organisms (GMOs), most European companies have been reluctant to invest in plant biotechnology. This situation has led to an undesirable *status quo*, in which no alternatives for harmful pesticides are developed, and promising new DNA technologies remain unexplored.

The Target Crops in BIOEXPLOIT

This Integrated Project will focus primarily on wheat and potato—the two most important staple crops for all consumers in the EU—for which pesticides, mainly

fungicides, are indispensable at the moment. Despite their importance as food crops for Europe, investment in genomics and post-genomics research on potato and wheat has lagged behind rice or even tomato. In addition, potato and wheat are not the species of choice for the scientific community to unravel disease resistance, and, as a consequence, basic knowledge and tools to design new resistances are often poorly developed. In the coming years a critical mass on genomics research in potato and wheat will be essential to strengthen the competitiveness of European SMEs in plant breeding. Despite the expansion activities of multinational companies in Europe, SMEs still play an important role in plant breeding. However, the opening of the European market for GM food and the increasing possibilities to grow GM varieties in Europe will result in a new situation in which innovation is of the utmost importance to survive in a highly competitive market.

General Strategies

The aim of this EU project is to force a break-through by developing efficient and rational breeding strategies using genomics and post-genomics tools to exploit natural host-plant resistance. Two strategies will be followed to design new resistant varieties: (i) marker-assisted breeding and (ii) genetic engineering. In the shade of the discussions on GMOs, marker-assisted breeding has gone through a silent revolution and has become a realistic option for developing new varieties with multiple resistances. The development of high through-put technologies for selecting plants at the seedling stage will considerably shorten the time between the first cross involving wild species and introduction of a variety on the market. For some crops this could even be a shortening by 50%.

Genetic variation in wild accessions of crop species and in their wild relatives is still largely unexplored. It has been estimated that less than 0.1% of the biodiversity in resistance is being used in commercial varieties. A major goal of this project is to exploit these genetic resources for designing resistant varieties, either made with or without genetic engineering. The relative importance of genetic engineering for the SMEs to develop new varieties for the regular market in this project is still difficult to predict and will depend on the attitude of the consumer. The fact that these GM approaches will only use natural plant genes, which have been used for more than 50 years in traditional plant breeding, may have a positive effect on the attitude of the European consumers.

Regardless of public opinion towards GM crops, marker-assisted breeding will have a high priority in this project, because it is according to various opinion leaders compatible with organic farming. In addition, in view of the continuous advances in developing new high through-put technologies, it is expected that in many situations marker-assisted breeding will become more efficient than genetic engineering, even without considering the time consuming and costly procedures to introduce GM varieties on the market.

Considering the commercial activities of the European plant breeding industry, the results of BIOEXPLOIT will also have a major impact on various other crop species.

Specific Strategic Objectives

Four specific strategic objectives will be addressed in BIOEXPLOIT:

1) To understand the molecular components involved in durable disease resistance;
2) To explore and exploit the natural biodiversity in disease resistance;
3) To accelerate the introduction of marker-assisted breeding and genetic engineering in the EU plant breeding industry;
4) To coordinate and integrate resistance breeding research, to provide training in new technologies, to disseminate the results, and to transfer knowledge and technologies to the industry.

The BIOEXPLOIT project will address its strategic objectives within eight subprojects as shown below.

Strategic Objective 1

The first strategic objective is to understand the molecular components involved in durable resistance. It includes the following three sub-projects:

Sub-project 1. To identify targets for durable resistance by analysing fungal effector molecules.
Sub-project 2. To map, isolate and characterise genes responsible for qualitative and quantitative disease resistance in potato and wheat.
Sub-project 3. To unravel the molecular mechanisms underlying innate resistance to plant pathogens.

Strategic Objective 2

The second strategic objective is to explore and exploit the natural biodiversity in disease resistance. It includes the following sub-project:

Sub-project 4. To explore natural biodiversity on genetic loci associated with disease resistance in wheat and potato accessions in gene banks.

Strategic Objective 3

The third strategic objective is to accelerate the introduction of marker-assisted breeding and genetic engineering in the EU plant breeding industry. It includes the following three sub-projects:

Sub-project 5. To increase disease resistance in potato and wheat through marker-assisted breeding.
Sub-project 6. To increase disease resistance in potato and wheat through genetic engineering.
Sub-project 7. To coordinate and integrate research and to provide training.

Strategic Objective 4

The fourth strategic objective is to coordinate and integrate resistance-breeding research, to provide training in new technologies, to disseminate the results, and to transfer knowledge and technologies to industry. It includes the following sub-project:

Sub-project 8. To disseminate the results and to transfer technology to industry.

Further Information

Further information on this project can be found at the public website: http://www.bioexploit.net.