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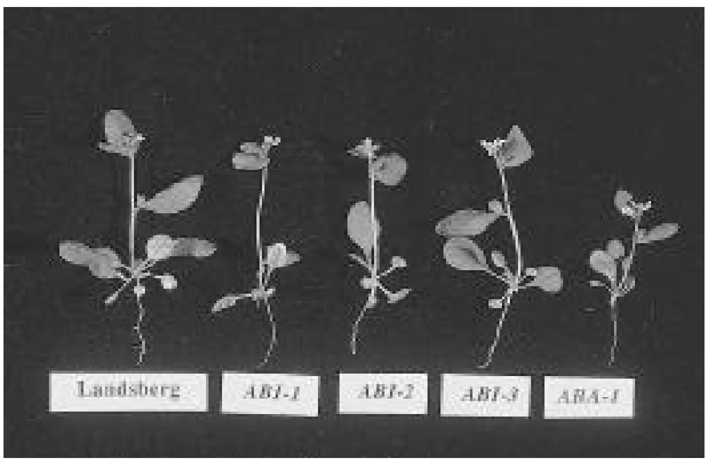
Arabidopsis: Model plant in biotech research

Plants are essential for human life. They replenish the oxygen we breathe, produce our food, shelter and clothing, and provide our industries with raw materials.

Despite their importance, much basic research on plant functions still needs to be done. For example, scientists need to learn more about how plants grow, how they protect themselves from disease or insects and how they respond to their environment. One of the best ways to do this is to study the information encoded in a plant's **DNA**, the material which makes up its **genes**.

Researchers soon realized that understanding the physical make-up and development of plants is most quickly achieved by studying one specific plant, which has similar characteristics or is related to important plant species. The advantage is that many scientists can study the model plant at the same time. The information gained from studying its genes can then be applied to many other types of plants. It's possible to do this because many flowering plants share similar characteristics.

Model plant



Young Arabidopsis plants

One common model plant is called ***Arabidopsis thaliana***. A member of the mustard family, it has several advantages for plant researchers:

• It develops, reproduces and responds to stress and disease much the same as many crop plants.

• It produces many seeds and is easy and cheap to grow, since the plant is small and requires little space. It also has a short life cycle.

• The low cost of production allows extensive genetic experiments on thousands of plants at once.

• Compared to other plants, it has a small **genome** (all of the plant's genes) and its genetic information is less complex. This makes it easier to do genetic analysis.

• It is the first plant to have its genome sequenced (mapped) due to an internationally coordinated program.

It is the last point which is so important to biotechnology research. Once a gene is mapped in the *Arabidopsis* genome, the equivalent gene or **homologue** can be more easily found in other plants. The functions of many crop genes can be better understood by studying their counterparts in the model plant.

Genetic information from *Arabidopsis* has been used to understand physical processes in other crop species such as canola and other ***brassicas*** (members of the cabbage family) like cauliflower, as well as peas, flax, tomatoes, peppers, soybeans, rice, maize, wheat, barley, rye, potatoes, cotton and sorghum.

Arabidopsis research is most relevant to closely related plants, like canola. *Arabidopsis* is a **dicot**, meaning that the seed has two halves. Cereals like wheat are **monocots**, meaning the seed does not split neatly in two. However, the genetic make-up of the model plant contains similarities to the genetic make-up of cereals, so its study still offers useful information to cereal researchers.

Advantages to collaboration

Since many researchers around the world are working on *Arabidopsis* at the same time, their collective efforts have produced additional biotech tools. These include:

•Synthetic **DNA markers** for mapping the genome. DNA markers are segments of DNA found near a desired gene. Synthetic markers can be more easily reproduced in the lab.

•Identification of natural **mutations** or alterations. For example, to study flowering, researchers can use a mutant which has a tendency to flower late, and another one which has a tendency to flower early.

•A combined collection of genetic maps, used in gene **cloning** (reproduction) and gene analysis. It is estimated that a complete map of the 20,000 genes in the *Arabidopsis* genome will be available in two years or less.

Applications of Arabidopsis research

Information from *Arabidopsis* can be used in several ways. Following are a few examples.

Crop flowering:

Researchers are interested in controlling flowering time and maturity date in crops, in order to adapt them to specific locations. For example, in Saskatchewan, where farmers can have a late spring and an early frost in the same year, early-maturing crops are an asset.

So far, plant breeders have used conventional methods to manipulate flowering time and maturity date in crops like canola. Now, studying how flowering time can be controlled in *Arabidopsis* provides researchers with information on how this might be done through **genetic engineering** (selective alteration of genes) of canola.

Scientists have found the *Arabidopsis* genes which promote early flowering, and those which delay flowering. Since the gene maps of *Arabidopsis* and *brassicas* are quite similar, researchers were able to find some of the equivalent genes in canola. They are now looking at whether these genes have the same function in canola as they do in *Arabidopsis.*

Resistance to microbial disease:

Plant breeders have long known that certain crop strains are more resistant to disease caused by viral, fungal or bacterial **pathogens** (disease-causing agents). Through their efforts to develop more disease-resistant varieties, plant breeders have managed to identify some of the responsible genes. However, there is still a great deal of work to be done in order to understand the details of how these genes actually work.

Studies on *Arabidopsis* are providing some of that understanding. The basic strategy is to work with *Arabidopsis* mutants that show either greater or reduced resistance to a specific pathogen, then to apply the knowledge to genetically engineer crop plants.

For example, researchers isolated the gene which gives wild *Arabidopsis* plants resistance to a common bacterial pathogen. They did this by developing plants in the lab which were susceptible to the bacteria. Examining the genetic make-up of the susceptible plants led to the discovery of the resistance gene in normal plants. Then researchers discovered that the plant's defence mechanism is likely triggered through the function of a specific protein.

Through this work, it was discovered this resistance gene is similar to another one which provides resistance to a fungal pathogen. These two *Arabidopsis* genes were found to be similar to disease resistance genes in crop plants, including tobacco, flax and tomatoes.

Researchers are determining if the crop genes work to provide disease resistance in the same way as the *Arabidopsis* genes.

Creating new oilseeds:

The *Arabidopsis* genes that guide the production of oils are closely related to those that produce oils in crops like soybeans and canola. The understanding of these genes has been used to identify corresponding genes in oilseed crops.

Vegetable oils contain high levels of **polyunsaturated fats**, which have many health benefits. However, when the oil is made into products like margarine, it must go through a process called **hydrogenation** in order to turn it into a solid. Hydrogenation makes the margarine less healthful than the original oil.

Information from studying *Arabidopsis* has been used to genetically engineer crops with lower levels of polyunsaturated fats. The goal is to eliminate the need for hydrogenation in commercial processing, providing a margarine which contains more of the health benefits of polyunsaturated fats.

Growing benefits

The benefits of using a model plant to understand basic plant processes are significant. By mapping the *Arabidopsis* genes and discovering how they function, researchers are able to apply that information in genetic engineering of crop varieties with disease and insect resistance, and other enhanced production qualities. The benefits will continue to grow as scientists work toward completing the map of the entire *Arabidopsis* genome.

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