RESEARCH AT A GLANCE

Biotechnology and Genetic Resource Policies

What Is a Genebank Worth?

Brief 10

Strategies for Timely Evaluation of Genebank Accessions

Bonwoo Koo and Brian D. Wright

The importance of plant genetic resources as building blocks for crop improvement has grown with recent advances in biotechnology and scientific information. The lack of useful data about accessions is frequently cited as an obstacle to greater utilization of genebanks by plant breeders (Wright 1997). In this context, we can invoke again the analogy to a library for the importance of relevant information, as discussed in Brief 7. If there are no data on the title, keyword, or other relevant information about the books held in the library, they will rarely be used, and the value of the library will be small.

Evaluation data are of the greatest value to plant breeders seeking to improve traits such as resistance to particular pests and diseases. Due in part to financial constraints, it is usually the case that only a small fraction of samples in genebanks are accompanied by evaluation data (Peeters and Williams, 1984). The dearth of supporting data has led some plant breeders to demand more extensive evaluation of genebank materials, although not all agree. The important policy questions for genebank management include when genebank managers should evaluate their materials and how new technological tools should change this decision.

Breeding for disease or pest resistance provides an illustrative example. Some diseases or pests cause chronic losses, and the rate of mutation in the pathogen is high, so that breeders are continually in search of new genetic mechanisms conferring resistance. Other types of diseases or pests occur rarely, with devastating losses. Identifying a novel source of resistance before infestation of a disease incurs significant costs. If the problem of disease infestation is unlikely to occur frequently, then in hindsight it usually becomes clear that the money spent for prior evaluation was wasted. On the other hand, if evaluation is initiated after the disease occurs, excess prior evaluation is avoided, but social losses due to crop damage accumulate during the delay before the release of the new variety. For example, the estimated damages of $670 million caused by Russian wheat aphid in the U.S. during the late 1980s might have been mitigated if the sources of resistance had already been identified (Russian Wheat Aphid Task Force 1991). In contrast, when barley stripe rust fungus devastated barley crops in South America after its arrival from Europe in 1975, plant breeders in the United States worked to identify sources of resistance to the disease and were already breeding resistant varieties when the disease reached the Unites States in 1991.

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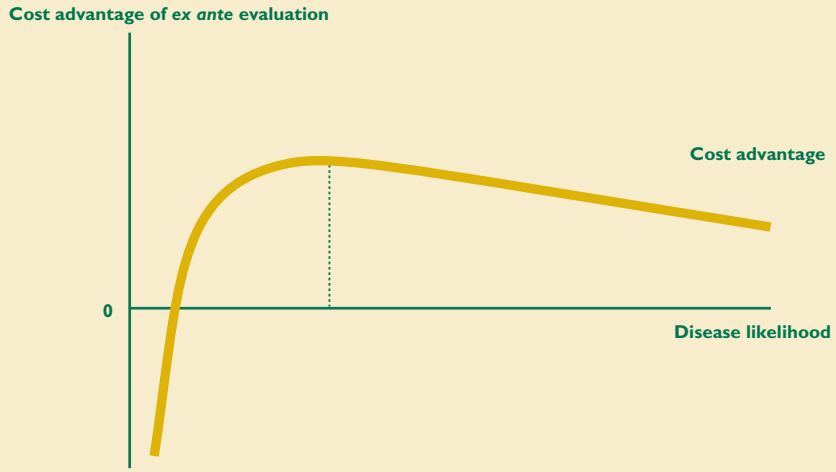
Timing of Evaluation

With limited resources and the numerous materials found in a collection, a genebank manager cannot search ahead of time for all possible traits of all genebank collections. Most managers choose to delay evaluation of the collection until after disease infestation (*ex post*), which is justifiable if the trait is expected to be used infrequently in the future. For a rare disease, the cost of searching at present is great relative to the expected present value of the benefits captured later. *Ex ante* evaluation may be preferred for a disease that is more likely to cause an infestation soon, because it reduces the expected social losses associated with the disease during the period of evaluation and variety development. Examples include Australia's development of locally adapted cultivars resistant to wheat stem rust (McIntosh and Brown 1997), and the strategies for breeding nonspecific resistance to stem, leaf, and stripe rusts of wheat at the International Maize and Wheat Improvement Center (Rajaram, Singh, and Torres 1996).

The likelihood of disease infestation provides a signal to a genebank manager regarding evaluation priorities. If a disease occurs rarely, early evaluation is less attractive. If a disease is expected to occur soon, the trait will be evaluated in any case, and the importance of timing the decision is reduced. Figure 1 shows the graph of a cost advantage of *ex ante* evaluation as a function of the likelihood of disease infestation. The size of the cost advantage indicates the degree to which *ex ante* evaluation is preferred to *ex post* evaluation. The advantage of *ex ante* evaluation does not continue to increase after the likelihood of disease infestation reaches a certain point. The benefit from *ex ante* evaluation is largest when the likelihood of disease infestation is at an intermediate rather than a maximum level. A genebank manager should therefore pay greater attention to the timing of evaluation when the likelihood of a disease infestation is in the intermediate range.

FIGURE 1 **The cost advantage of *ex ante* evaluation and likelihood of disease infestation**



The Role of Biotechnology

Recent biotechnology innovations have made evaluation for resistance traits and development of useful cultivars incorporating these traits cheaper and faster. Genetic marker techniques and genomic information reduce the time spent evaluating for some resistance traits. In principle, genetic engineering techniques can expedite plant breeding by enabling the insertion of genes into backgrounds that are proven to be popular without linkages to other, undesirable genes that would have been eliminated through backcrossing with conventional means. Although we often assume that the use of tools that speed evaluation and development would favor *ex post* evaluation for resistance to disease, the opposite appears to be the case. The explanation for this result is that the marginal benefit from the technological breakthrough is larger when the development process is started earlier.

Implications

The agricultural environment is continuously changing, and so is the demand of plant breeders and other scientists for genetic resources. Predicting the future use of accessions stored in genebank collections is difficult. The timing of the evaluation of accessions is an important issue for genebank managers. A commonly expressed view is that all traits likely to be relevant in crop improvement should be completely evaluated *ex ante* in order to facilitate and encourage the utilization of the genebank by plant breeders. This analysis shows

that for a trait that has a low probability of being needed soon, *ex ante* evaluation tends to be dominated by delayed evaluation. This finding has meaning for genebank managers who face chronic funding problems. Instead of spending scarce financial resources for the expensive evaluation of rarely used genes, it may well be more efficient to focus on other activities such as the provision of basic information and the construction of a network to enable better information flow (Frankel 1989). Technological breakthroughs that reduce the cost and speed of evaluating accessions and developing cultivars will encourage *ex ante* evaluation. The economic implications of various managerial strategies for evaluating genebank accessions will need to be revisited as the science becomes better understood.

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For a more detailed version of this summary, see the following:

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