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# Biotechnology and Genetic Resource Policies

## What Is a Genebank Worth?

Brief 8

## SEARCH STRATEGIES AND THE VALUE OF A LARGE COLLECTION

Douglas Gollin, Melinda Smale, and Bent Skovmand

While the agricultural productivity benefits of utilizing new germplasm have been widely documented (Evenson 2001; Alston, Norton, and Pardey 1998), some controversy remains about the economic justification for expanding existing collections of crop genetic resources. Concerns persist that germplasm collections are underutilized (Wright 1997) and therefore of questionable economic value. Does infrequent “use” of genebanks in crop breeding programs imply that accessions in genebanks have little economic value? Are seed banks really “seed morgues”?

This study was motivated by criticisms that because plant breeders seldom “use” genebank accessions directly in their breeding programs, there appears to be little justification for maintaining collections. The approach builds on earlier work by Evenson and Gollin (1997), examining more closely the relationship between genebank activities and crop improvement. A search theoretic framework invoked previously for the cases of sugarcane breeding (Evenson and Kislev 1976) and the pharmaceutical industry (Simpson, Sedjo, and Reid 1996) was applied to the analysis of genebank decisions with actual data from searches for new sources of disease and pest resistance. Findings shed some light on the optimal size of collections and on the circumstances in which large genebanks have economic value.

Economic principles dictate that a search should proceed until the expected gains from searching an additional accession are outweighed by the additional costs of the search. The expected gains are defined as the product of two factors: (1) the discounted stream of future benefits from finding the trait and (2) the change in the probability of success from searching one more accession, where the probability of success is the chance of finding an accession with the desired trait in a search of a given size.

Three specific questions on genebank management are answered with numerical experiments on data from past searches and wheat variety diffusion in regions of the developing world.<sup>1</sup> The first case, about the Russian wheat aphid, demonstrates that the probability of finding a targeted trait is extremely sensitive to the frequency distribution of the desired trait among the accessions searched. This distribution in turn depends on the breadth and size of the collection from which the materials are drawn and the distribution of the trait in the underlying plant population. The rarer the source of new resistance, the larger the search needed, and by implication, the larger the collection. A

<sup>1</sup> The sources of data for this analysis include the International Maize and Wheat Improvement Center (CIMMYT) and the Genetic Resource Information Network of the National Small Grains Collection at the U.S. Department of Agriculture.

problem of global importance clearly warrants a large search effort, implying a collection of large size.

As in any analysis of the benefits from crop improvement, the discounted stream of future benefits depends on how long it takes for plant breeders to transfer the new source of resistance into the variety, the time it takes for the new variety to pass regulatory hurdles, the magnitude of the “problem” to be resolved, and the popularity of the new variety among farmers. The variety’s popularity in turn depends on how well adapted it is to local production conditions, how heterogeneous these conditions are, and other constraints farmers face in purchasing seed or related inputs. In the “problem” of coping with yield lost to diseases or pests, the crop breeding process is a race for the development and release of varieties with novel sources of resistance against evolving strains of plant pathogens or pests. The time value of money—or the perspective of the research investor—is a critical parameter in projecting the magnitude of the benefits.

The second experiment illustrates the value of specialized knowledge concerning the “location” of resistance in the collection. The capacity to focus or target a search generally has large payoffs. A priori knowl-

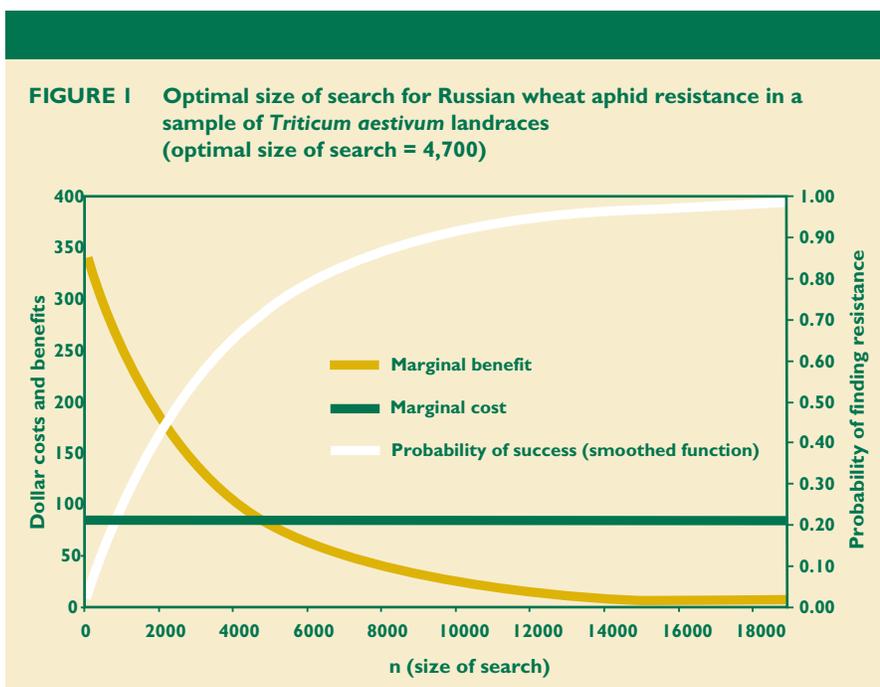
edge that accessions from a given geographical area (in the case of Russian wheat aphid, Iranian landraces<sup>2</sup>) are likely to be more resistant to a pest dramatically reduced the search size required and increased the expected net benefits from the search (Figure 1).

What is the basis of this knowledge? It may be held by a few experts or by public databases.

The third experiment indicates why plant breeders avoid tapping categories of genetic resources that are “raw” or unimproved and incompletely characterized. Resistance to Septoria leaf blotch is far more common among accessions of emmer wheat than among elite breeding lines, but the costs of evaluating emmer and transferring resistance into materials that are ready for release to farmers is high. This case shows that it may be efficient not to focus on the accessions known to be more resistant if the relative cost of moving this resistance into varieties that can be rapidly released and adopted by farmers is high.

This study clarifies some essential points about the valuation and utilization of genebanks. First, the empirical examples suggest strongly that large genebanks have substantial economic value for agricultural crops such as wheat. Wheat is an intensively

bred, major world cereal crop. There are occasional situations in which the chances of finding a trait are slim and the economic payoff to discovery is great. These are the situations from which large collections derive their value. There are other occasions when the trait of value is found in a tiny subset of the world’s collections of genetic resources, such as a set of landraces from a particular geographic location. Although they may be searched rarely, there are reasons for storing them “unused” for years. Most importantly, the casual observation that plant breeders reach into their own collections more frequently than they



<sup>2</sup> The term *landraces* originally referred to livestock breeds, but is now often used to describe traditional or farmers’ varieties of crops that are the product of breeding or selection by farmers in their own communities over a number of years. Unlike commercial cultivars that must be recognized as distinct, uniform, and stable, a landrace is typically heterogeneous and may contain rare alleles or gene complexes because of its local adaptation.

demand unimproved materials from genebanks in no way implies that the latter have no value. Certainly survey evidence shows that the crossing blocks of plant breeders themselves hold significant genetic reserves (Brennan et al. 1999; Rejesus, Smale, and Van Ginkel 1996), and Duvick (1984) has argued that the genetic base of elite germplasm provides more useful diversity of traits than is often assumed. For reserves held in banks, however, short-term payoffs may be modest while long-term payoffs are great, especially when considering the multiple traits for which the same accessions can be searched.

While genebank managers can attend to the content of their collections and their management, it is clear that many factors outside their control determine the magnitude of the economic benefits from finding and transferring traits into crop varieties. In some cases, forecasts of future benefits can be grounded on past calculations of benefits and patterns of variety diffusion. As argued in Brief 7, however, the use of economic principles (e.g., marginal benefits equals marginal costs) in deciding which accessions to keep or discard is not so straightforward as it may seem. The range in total discounted net benefits from searching for and finding a new source of resistance to Russian wheat aphid was enormous—more than \$165 million—warranting a search that was larger than the total number of wheat landraces in the CIMMYT genebank.

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For a more detailed version of this summary, see

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