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The Canon of Potato Science:

1. Genetic Diversity and Genebanks

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What is it?

Genebanks manage germplasm—raw materials for breeding and research. The purview of genetic diversity and genebanks with respect to the potato crop is the wild and cultivated tuber-bearing members of genus *Solanum*, perhaps also some very closely related non-tuber-bearing taxa. Potato is extraordinary in its breadth of related wild species (typically populations maintained as botanical seed), that are relatively amenable to use in cultivar breeding. There is also a great diversity of primitive cultivated landraces (maintained clonally as tubers or *in vitro*), and, of course, thousands of named clonal cultivars, breeding and genetic stocks from nearly 200 years of modern breeding. Capturing all diversity *ex situ* is beyond available physical and financial resources, so the challenge of genebank managers is to find the most efficient means to maximize their service with respect to the five genebank functions:

1) Acquisition (novel collections from the wild or materials shared from other genebanks or donors);
2) Classification (research toward stable and objective species boundaries);
3) Preservation (including research to inform decisions of best preservation techniques, and implies satisfactory success only when sufficient viable and disease-free propagules are available for distribution);
4) Evaluation and characterization (the former including useful traits like disease resistance, the latter assessment of basic features like ploidy);
5) Distribution (both propagules and information).

National potato genebanks vary in size and scope. Some have the goal of comprehensive representation of genetic diversity and international distribution. Others

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primarily keep the germplasm of their country and serve the needs of its own users. Germplasm may also be maintained by private organizations and public entities with a limited scope (e.g., state seed certification agencies and individual scientists' research programmes).

Why is it Important in Potato Science?

Germplasm contributes to breeding not only as materials *per se*, but accessions can also serve as models with extreme expression, which helps to research the genetic and physiological bases of traits. It has been estimated that about half of the contribution to crop improvement is genetic, a substantial part of which depends on the use of exotics to meet challenges from emerging pests, diseases and stresses. One way to gauge the importance of genebanks is to imagine the difficulties potato scientists would face without them. Human impact on habitats has increased, threatening loss of *in situ* wild diversity. Similarly, modern breeding has fine-tuned production such that often only a few outstanding cultivars are grown over vast areas. Thus, the diversity historically maintained on the landscape would be lost unless these genetic resources are artificially preserved in genebanks. But even if the diversity was securely available *in situ*, potato science would be greatly handicapped without the service of genebanks. Imagine the inefficiency of requiring every scientist to become an expert in taxonomy, collecting, international germplasm exchange, quarantine restrictions, and to be required to study and determine crossing behaviour, cultural requirements, preservation technology, and to acquire the specialized equipment needed to maintain exotic germplasm. The worst part of such a scenario is that there would be no organized system for long-term preservation of all the germplasm that had been acquired by various scientists and making it available to all others, nor the comprehensive collection, organization and dissemination of germplasm information to all interested potato scientists.

Why is it Important for the Potato Industry?

Cultivated potato passed through a genetic bottleneck during its early emigration from Latin America and development in Europe, and subsequent adaptation in North America and other major worldwide production areas as *S. tuberosum*. Thus, the crop is generally considered to have a narrow genetic base, a particular disadvantage in a crop exhibiting severe inbreeding depression. This also translates into relatively high cultural input requirements to compensate for weaknesses for which there is no genetic solution in the breeding pool. Just as a mechanic can do better business with a well-stocked toolbox, the potato industry has greater potential when its cultivar breeding pool has a broad array of genetic tools to deploy. Thus, genebanks' contributions of genetic diversity benefit the industry in two ways. Genes are introgressed to confer specific needed traits, and inputs of general allelic diversity increase heterozygosity and counteract inbreeding (i.e., promote heterosis). Why then do we observe that while exotic germplasm has been used to great advantage in potato breeding (much more than in most other major crops – see "*Further Reading*"), relatively little has been used in comparison to the great breadth of materials available? Part of the explanation is that the profit that would motivate use of exotic germplasm is found in markets in which potatoes have very exacting quality standards, making selection of acceptable new cultivars using unadapted parents much more challenging. Some of the developments noted in the next section promise to improve this situation.

Scientific Developments

Advances in Breeding Tools:

- Mapping;
- Genetic transformation;
- Marker assisted selection for breeding and germplasm screening;
- Crossability systems (EBN);
- Protoplast fusion;
- Haploids and 2n gametes.

Changing Breeding Needs:

- Processed versus fresh product traits;
- Cultivation of True Potato Seed;
- Breeding for Asia;
- Climate and demographic changes, e.g., requiring more drought and heat tolerance, changing pest and disease dynamics or limited inputs (better water and agrichemical use efficiency due to limited availability, higher cost, or restrictions on their use aimed at protecting environment and human health);
- Enhancing *positive* health-related quality traits like antioxidants, anti-cancer, potassium, vitamin C, and reducing *negative* ones like glycemic index and acrylamide.

Developments in Genebank Management:

DNA markers for fingerprinting to verify unique clonal identities and to allow elimination of duplicates, determine similarities for a "core subset" which represents most of the genebank's available diversity in a much smaller selection of stocks, refine taxonomic boundaries, and monitor the dynamics of diversity such that its preservation can be maximized over the many technical steps of collection, preservation, and evaluation that involve sampling.

Intergenebank Collaboration:

Association of Potato Intergenebank Collaborators, (APIC), to share technology, global preservation responsibilities, referral of clientele, evaluation data on stocks duplicated in each others' bank, and joint research and collecting.

Further Reading

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