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Is Wheat Variety Development in Canada Open Source?

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The Issue

Software developers are increasingly utilizing the open source development methodology to create both novel and incremental software innovations. Open source software allows developers access to the source code, which can then be used to troubleshoot or modify the program for a new application. Instead of rewriting an entire program, a developer can incrementally improve an existing program without worrying about infringing on property rights. The open source web browser Mozilla Firefox is an example of the open source approach to software development. Numerous updates and add-ins are available, ranging from media player controllers to search tools, blogging support, and many others. Individuals looking to fill a niche developed these add-ins, which occurred only because the core software (Mozilla Firefox) is open source. Over time the add-ins become integrated into the software's core and a next generation of add-ins are developed and integrated.

An interesting parallel can be made between the open source development niche in the software market and the publicly funded wheat variety development niche in the crop variety market. The variety registration regulatory system and accompanying Plant Breeders' Rights Act combine to create a *de facto* open source system for wheat variety development. In this instance, hundreds of years of previous breeding work provide a cumulative core for innovation, and the incremental improvements to yield, disease resistance, and agronomic traits are the subsequent innovations or add-ins. Over time, the incremental improvements become part of the core. This relationship cycle between the core and subsequent innovations has been occurring for centuries, and has produced many useful wheat varieties. It seems as though the benefits and flexibility that are driving the expansion of open source software development are already contained within the current wheat plant breeding system.

This policy brief examines the variety development methodologies that are used by wheat breeders in Canada and compares them with the open source methodology that is currently being used to develop computer software. It appears, however, as though the computer software development industry and the wheat breeding industry are moving in opposite directions. Where software developers are seeking more open access to development tools, wheat breeders are considering more restricted access.

Plant Breeding Background

The type of organization that most efficiently undertakes plant breeding activities varies depending on the attributes of the selected crop and the country in which it is grown. As a general rule, in countries or for crops that have a mechanism that allows for recurring sale of seed to farmers, privately funded plant breeding activities tend to develop. In countries or crops that lack such mechanisms, publicly funded or farmer funded plant breeding activities are developed. It is

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important to note that whether public or private, the success of any breeding program will depend on access to genetic variation and the ability of the breeder to integrate genetic variation into a program.

The sources of genetic variation available to plant breeders are finite. In a typical wheat breeding program, the sources of genetic variation available to a breeder include (in order of importance): breeding lines from his own program; breeding lines from a program in a similar climate; registered varieties; chemicals or radiation to induce mutations into a breeding line; and, finally, landrace species. Although all five methods are used, most registered varieties have been created using the first three sources. Two of these often used sources result in a breeder using material from other breeding programs. The importance of plant breeders being able to access these finite genetic resources from other programs and registered varieties is paramount for the successful development of new plant varieties. Plant breeders, both public and private, need to be able to share germplasm amongst themselves as freely as possible.

Open Source Software Background

Computer software development is a widespread industry comprised of a number of developers, all with unique incentives. It seems as though most software developers want to create a useful product, but they differ in their motivations for producing a useful product. Private software developing companies such as Microsoft tend to produce software for a profit. Individual software developers (such as those involved in the creation of the Linux operating system) tend to produce software for their own use and/or greater extent peer recognition (Lerner and Tirole, 2002). Still other companies, such as Apple, distribute their proprietary software for free because having people use their software allows them to sell a separate service.[1]

In order to develop a new software application, the programmer must go through a two-stage process. During the initial stage of development, the instructions or source code is keyed into a computer using a written language. Computer processors do not understand the written languages used by programmers, so, after the source code is completed, the written program must be converted to a set of binary numbers that can be read by the computer's processor. This two-stage conversion process is a necessary step because it is impossible for programmers to code in binary.

This conversion process is a significant source of protection and excludability for profit-motivated software developers. When the source code is converted into binary code, it is impossible for others to see how the software is written and make adjustments or borrow the source code for their own use. Thus, for-profit software creators generally only sell closed source software—that is, software with only the binary version of the source code included (Hope, 2004).

Selling closed source software may be a benefit to profit-motivated developers, but it is an impediment to software users who demand flexibility in their programs. In order for software users to customize their programs, they must be able to access the source code. Software programs that come with both the binary and written versions of the source code are known as open source. The notion of being able to access a program's source code and make customized modifications to it, plus accepting that a piece of software program is never complete and can always be improved upon, drives the continued expansion of the open source software movement (Steely, 2004). Open source access facilitates the sharing and dissemination of programs.

Wheat Development is a *de facto* Open Source System

The requirements that the merit-based variety registration system puts on wheat breeders, coupled with the current Plant Breeder's Rights Act based on the 1978 revision of the International Union for the Protection of New Varieties of Plants' Act (UPOV-1978), combine to facilitate an "open source" wheat varieties in western Canada. Table 1 describes the key points that make a software program open source and then compares the points as to how wheat varieties are bred, registered, and protected in Canada.

The source code in open source software is equivalent to the pedigree information for a new plant variety.

In order for software to be considered open source, the source code must be freely available to users. Providing the source code with the program allows a user to modify and troubleshoot the existing application, as well as to determine what makes it work. Before any wheat variety is registered in Canada, its source code or pedigree information and breeding method has to be published in a peer-reviewed journal.[2] A description of how the variety was created transfers tacit knowledge that allows other variety developers to analyze the breeding techniques and breeding lines used. Providing the source code or pedigree information is therefore analogous.

Other important comparisons can be drawn using the subsequent modification conditions of the open source license. The fundamental principle of open source is that no entity can restrict the use (alone or with another application) or modification of open source software. This principle is in direct alignment with two key provisions in the Canadian Plant Breeder's Rights Act. The first notable provision is the breeder's exemption. Once a variety is registered, it is available, royalty-free, to any other breeder to use in crosses so as to produce a new variety. The registered variety becomes part of the core of materials available. The breeder cannot restrict further use and/or modification of a variety any more than a software programmer can restrict the use and modification of the source code. The second provision that is similar to open source is the farmer's exemption. After buying certified seed of a variety protected by plant breeder's rights, a farmer is free to keep the seed and reuse it the next year.

Table 1. Comparison between open source software and "open source" germplasm.

Open Source Condition	**Software Perspective**	**Public Breeders' Perspective (UPOV, 1978)**
The source code must be available to the user.	The software distribution must include the original programming language. If not, the source code must be made available by free, public internet download.	All publicly bred wheat varieties registered in Canada must provide pedigree information.
The software must be modifiable and the creation of derivative works must be permitted. The software must be redistributable.	All users are given the right to modify the software or produce derivative works. The user of open source software is given full rights to reproduce and redistribute the software on any medium, to any party, either free or for a fee.	Farmers and breeders' are both users of varieties. Farmers are allowed to reproduce the variety and use it themselves next year. Farmers are not permitted to sell seed to other farmers. Breeders can freely modify (cross-)varieties, and new varieties based on old ones are allowed royalty free.

Adapted from Feller and Fitzgerald, 2000.

One difference between open source and a plant breeder's rights, however, is the point where the software must be redistributable. This point is in agreement with a breeder's use of an existing variety, but is in disagreement with a farmer's use of an existing variety. Legally, if farmers grow a crop protected by the current *Plant Breeder's Rights Act*, then they are not allowed to sell the seed from that crop to another farmer for seed use. Farmers are allowed to grow and reproduce the protected variety for their own use, but not to sell seed to others at a common grade or otherwise (Berg and Recksiedler, 2005).

Potential Threats To Open Source Wheat Breeding

The UPOV 1991 agreement was written with the intent of striking a balance between the reality of plant breeding being incremental in nature and the incentives needed to allow breeding companies to invest in the process. As a compromise, the agreement incorporates a slightly different breeder exemption scheme. The agreement grants a breeder exemption on all protected varieties if they are not given initial variety status. Plant breeders are still allowed to use non-initial varieties in future breeding efforts without having to pay royalties to the original breeder. The only varieties that are use restricted are those that have been granted initial variety status.

There is a significant problem with the new breeder exemption scheme included with UPOV 1991. First, it is not clear what criteria a variety has to meet in order to be granted initial variety status. Currently, initial variety status is granted through litigation between two breeders after the variety and subsequent varieties are registered. So, breeders who are using a variety in their program may or may not be using an "initial" variety, depending on the outcome of a court decision. This uncertainty has the potential to restrict breeders' willingness to access the core set of genetic resources.

The use of material transfer agreements (MTAs) has direct and indirect effects on the open source nature of plant breeding. In spirit, most MTAs written to transfer wheat germplasm provide incentives for redistribution. However, the mere fact that they are there increases the costs to share genetic material. Breeders are less likely to spend scarce time and resources to acquire genetic material that has a low probability of being implemented into their own breeding program if there is a cost attached.

Another potential threat to the open source nature of plant breeding is the increased patenting of research tools. Increasingly sophisticated research tools such as molecular marker and transgenic technology have the potential to greatly increase the efficiency of incremental improvements to a core set of genetic resources. If these improvements are made using patented research tools, then there is a potential for them to not be added back to the core.

Conclusion

Software and plant variety development are practiced by different entities, each with different motivations. Two kinds of developers within these industries, wheat breeders and open source software developers, have common motivations and use similar development methodologies. Both developers utilize a core set of materials (registered varieties and open source software) to create subsequent incremental improvements. Unrestricted access to the core materials is what makes both methodologies function well.

Endnotes

[1] Apple distributes its iTunes software freely, which then allows it to sell multimedia files through its iTunes service.

[2] As an example, see DePauw et al, 2004 for a description of the bread wheat variety Lillian.

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