1 Farmers, innovation and intellectual property

Current trends and their consequences for food security

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Introduction

Food security depends on access to a sufficient quantity of nutritious food. With a huge and growing global population, an ever-increasing proportion of which has no involvement in the production or supply of food, innovation that enhances food security has never been more important. Crop improvement in terms of greater productivity and nutritional quality is an essential area for innovation. Of course, plant innovation goes back more than 10,000 years, without which there would have been no such thing as agriculture. For almost the whole period, it has exclusively been carried out by farmers. Its success has been dependent on the exchange of ideas and plant material, albeit not necessarily without restrictions such as those based on local norms opposing or constraining free access to all (Coomes et al. 2015). The professionalisation of plant breeding, done by scientists who are not themselves farmers, is comparatively recent. It has been advantageous in many respects. However, the ever-increasing pervasiveness of scientific breeding and the evermore exclusionary legal and regulatory norms that are integral to it has certain problematic aspects, which are all too rarely admitted. This chapter argues, first, that encouraging plant innovation in favour of food security entails a much wider appreciation of its diverse sources starting from the farm all the way to the biotech corporation, as well as a higher awareness of the social normative and legal context enabling such innovation to flourish. Intellectual property rights are alien intruders as far as small-scale and resource-poor farmers in developing countries are concerned. The idea of seeking monopoly protection over their cultivars is likely to be unthinkable to such farmers. Second, for policymaking farmer-centric approaches to innovation emphasising autonomy, freedom and openness, and utilising the capacity to innovate of small farmers, in collaboration or otherwise with scientific breeders, are necessary too. This is especially the case in developing countries where 'traditional' agriculture continues to resist the tide of top-down models of rural development, often driven by the pursuit of profit, that treat farmers as consumers of innovations produced elsewhere, possibly in a very distant location.

The chapter first explains what plant innovation is and how it has evolved over time. It then traces the separation of the practice of breeding from cultivation and shows how, as time went by, new legal norms – mostly patents and plant variety protection (PVP) – came to predominate and have become global in their application. The implications for food security and for the small-scale farmers, who continue to be vital providers of food throughout the world, have been mixed. Food production globally has soared, yet food security remains a huge problem with millions going hungry or suffering from diseases caused by poor nutrition. Meanwhile agricultural biodiversity is encountering huge stresses.

From a global history perspective, intellectual property rights, while apparently being the 'new normal', are in fact a recent and highly disruptive deviation from norms going back millennia. The same may be said for seed licenses. Meanwhile, the needs, interests, social norms, agricultural practices and innovations of small-scale farmers still tend to be overlooked.

Plant innovation: ancient, traditional and modern

Ever since the birth of agriculture, and possibly even before then, humans have done other than merely accept nature as we found it. The Neolithic adoption and spread of agriculture transformed the biosphere, turning untamed wildernesses into farmlands. Farming and crop improvement were carried out by the same people and in the same places: by farmers on the farm. From Neolithic times, farmers have set aside some of their harvested seeds for replanting. They selected such seeds, whether consciously or unintentionally, on the basis that the plants producing them possessed desirable traits such as high yields, disease resistance or drought or frost tolerance. Over the generations, this practice resulted in ever-increasing quantities of locally adapted varieties known as 'landraces' or 'farmers' varieties'. Ecologically speaking, agriculture involves arresting natural succession processes at a very early stage. By preventing the maturation of ecosystems, invasive species, often grasses like wheat, rice, barley and maize, remain dominant instead of giving way to trees (or other vegetation prevalent in mature ecosystems) as would otherwise happen without humans to prevent it by weeding, ploughing and burning. Wild plants and animals became domesticated ones, initially by becoming 'camp followers' taking advantage of the opportunities provided by human habitation to spread onto the disturbed terrain and scavenge for food. While human selection ultimately had a massive effect, 'domestication' in its early stages was not something that humans 'did'. Rather it was a normal evolutionary response to the formation of new ecological niches resulting from human settlement and activity that selectively advantaged individuals with certain traits. Such traits included tameness in certain animals and opportunism in plants. In time, humans would have preferred plant species that were edible and individuals tending to put their energies more into vegetative growth and seed production than in developing complex and extensive root systems (Budiansky 1992). Here human selection would have come into play. Far later, the will and capability to improve the world with a little hard work and ingenuity came to be seen by Europeans as one of the hallmarks of a civilised society.

The separation of the two activities of farming and breeding is very recent historically. In some parts of the developing world, though, it has hardly begun.

In late nineteenth-century North America and Europe, a marked divergence emerged between the occupation of farming and of seed improvement and production. Those engaged in the latter were selecting from the existing materials to increase their share in a growing market in commercial seed. This commercial crop improvement was empirical and experimental but with a growing scientific basis in mathematics applied to selection methods. Very soon after the 1900 rediscovery of Mendel's insights into the laws of heredity, scientists sought to apply genetics to crop improvement. According to conventional accounts, this led in good historically linear fashion to the directed development of 'pure lines' of self-pollinating crops. Pure lines, a term coined by Wilhelm Johannsen, are uniform, breed true to type and contain consistent and identifiable traits that can be transferred to other plants. According to Pistorius and van Wijk (1999), 'while Mendelian breeding allowed for a controlled mixing of genetic characteristics, pure line breeding offered a practical method to 'fix' them in succeeding generations'. It must be said here that debate continues as to how far the notion of the pure line truly transformed breeding practices and whether it was all that crucial in attracting new commercial interest in crop improvement (Berry 2014), but a deeper discussion falls beyond the scope of this chapter (e.g., see Bonneuil 2006). Suffice it to say that PVP is implicitly founded upon a pure line-derived conception of breeding practices and of what the 'new plant variety' by definition is.

Nowadays, the inputs for crop improvement work largely include earlier varieties that themselves were previously developed by the same improvement techniques. These form a large proportion of the stock of breeding material already in wide circulation among breeders. Thus, much plant breeding centres on the mixing or 'shuffling' of traits that are either known about already or else can be identified in easily accessible and well-characterised plant material. However, inputs also include varieties acquired from seed collections newly or only recently circulated as breeding material. In addition, varieties hitherto found within and around the fields of local and indigenous cultivators may also be used. In certain cases, such human populations inhabit areas within the centres of origin and diversity of major crops such as rice, wheat, maize and potatoes as were initially identified by the great early twentieth-century Russian geneticist Nikolai Vavilov. The centres, therefore, are strategically important in terms of food security, conservation and commercial activity in plant breeding and commercial biotechnology.

Plant innovation is inherently cumulative based on incremental improvements on what already exists. Much of what exists goes back thousands of years and has generally been freely available for everyone's benefit. Admittedly, modern field-crop breeders are not usually reliant on traditional farmers' varieties on an everyday basis, except when they are starting up new breeding programmes. Even then, this reliance is likely to diminish over time as they focus evermore on the recycling of modern varieties. However, local farmers' varieties (Halewood and Lapeña 2016; Louwaars and De Boef 2012) and wild relatives of crops (Castañeda-Álvarez et al. 2016; Montenegro 2016) continue to be extremely important for integrating new traits or new variants of known traits (e.g., disease resistance), and their continued use and existence is essential for breeders and local/indigenous communities alike. Being themselves conservers (through their use of agricultural biodiversity) and crop improvers (thought their selection practices and on-farm experimentation), many so-called 'traditional' cultivators provide an essential service to breeders and to those of us who do not farm and need others to provide sustained food security. Indeed, global food security can be enhanced by encouraging their use and by ensuring that access to them be kept open, subject to the rules and principles of the UN Food and Agriculture Organization (FAO) International Treaty on Plant Genetic Resources for Food and Agriculture, which establishes a multilateral system of facilitated access to plant genetic resources but respects national sovereignty and requires benefit sharing.

Incremental as it is, plant breeding is a very laborious and time-consuming process. It takes about seven to ten years to get from the first cross to the marketable variety. The first task is to determine the objectives of the breeding programme. One obvious goal is to produce varieties with higher yields, but there are many other possible objectives such as the development of varieties with added or improved characteristics such as pest resistance, disease resistance or drought tolerance; compatibility with inputs such as fertilisers and pesticides; and improved consumption or food-processing characteristics. A major challenge for breeders is to respond on the one side to the requirements of varying farming conditions, and on the other hand to the need to develop varieties that can be sold widely. Furthermore, they increasingly have to respond to the ever-changing demands of conglomerate seed and chemical companies, food-processing companies and supermarket chains.

The hyper-abundance of food products in the developed world and the reduction of mass hunger in a few developing countries are largely attributable to modern agriculture including the varieties in common use bred by public and private sector breeders. One must avoid being Panglossian about this. Overconsumption and the low-quality diets of many people, with all the attendant health problems from diabetes epidemics to malnutrition, are other consequences we can hardly sweep under the carpet. The modern food system is also highly dysfunctional. Putting these problems aside for just a moment, generating revenues from plant breeding is a challenge. This is significant if we accept as we should crop improvement's contribution to social welfare enhancement. For varieties that breed true, meaning they have consistent traits that persist generation by generation, farmers and even amateur gardeners can save, clean and replant or sell seeds. Asexually reproducing species can be mass copied through techniques such as cutting and grafting. In response, biological technologies such as those for producing hybrids, intellectual property and contract law – as applied through use of licenses that purchasing seed dealers and farmers must agree to – may be deployed so that breeders can derive revenue from plant varieties that they have developed.

The discussion is true as far as it goes but it largely leaves out today's small-scale farmers. There is a tendency to write off traditional small-scale systems as being obsolete, maladaptive and generally unproductive. One of the main reasons why we fail to respect traditional agriculture is perhaps that the word 'traditional' implies a rootedness to the past as if that is its defining and only feature. To suggest that traditional knowledge is old and therefore lacks novelty is an unhelpful presumption. It may well be true that these systems alone will never support today's global population, of which more than half is now urban dwelling, and that modern intensive agriculture based on high-yielding varieties and large doses of chemical inputs is vital.

Perhaps the difference between what 'scientific' breeders and small-scale farmers do with respect to crop improvement is overstated in a way that justifies intellectual property protection for the former and exclusion of protection for the latter. It was certainly not always like this. How plant breeders conceptualise their work, their role and the extent to which they intervene in and control nature has changed over the decades and not only on scientific grounds. Nowadays intellectual property and commercialisation are implicated in this as never before. As historian Berris Charnley (2015: 23–24) explains:

> In the 1950s and 60s, despite the US Plant Patent Act 1930 and UPOV, and the legal arguments around inventorship behind such legislation, many plant breeders still saw themselves as stewards of somewhat natural variability, rather than as inventors. The varieties they produced had to be constantly maintained, otherwise a variety might "run out", becoming heterogeneous and unruly. This stewardship role – enshrined in breeders' practices – was a key selling point in catalogues which proclaimed the length of time varieties had been maintained and purified […] Over the decades since mid-century the variety has slowly been ossified as a fixed and discrete unit. Variability has been recast within acceptable boundaries which do not threaten a variety's integrity. In the years since 1980, this conception of variety has in turn been displaced as the product of plant breeding by allegedly fixed identifiable entities around which intellectual property could be circumscribed, without the need for maintenance – DNA sequences.

This refusal to countenance the inevitability of natural variability is, Charnley argues, a fiction, and one which has wider implications: 'The law's recent focus on DNA sequences, as though they were static and unchanging over time, degrades the importance of stewardship roles (especially those conducted by small scale farmers in maintaining land races)' (ibid.: 24).

In fact, we need to go much further in changing the discourse. Small-scale farmers are the main providers of food security in many developing countries, and as mentioned, their sustainable production and their maintenance and use of agricultural biodiversity are a boon for all humans. So-called traditional farmers can be highly innovative in the face of fluctuating and unpredictable environmental conditions. One might call this 'invisible innovation'. Few efforts have been made to define, bound and quantify it. On the other hand, intellectual property protection requires that human creativity be fragmented into discrete units that form the tangible or intangible items that the legal monopoly surrounds.

Misconceptions hardly help. Contrary to what is frequently assumed, not all farmers' varieties are ancient; neither are they all 'traditional': sometimes there is cross-breeding with modern varieties (Kingsbury 2009: 65–66). Anthropologist Paul Richards (1999: 315–16) explains, for example, how Mende farming communities in Sierra Leone continue effectively to manage agricultural genetic diversity, experiment on-farm with traditional *and modern* rice varieties and to produce their own varieties whose performance is often better than those provided by extension services. Thankfully, there is some greater appreciation that agricultural innovation needs to be construed much more broadly to include small-scale farmers:

> More recently, the scope of what is considered agricultural innovation has broadened. It has become more widely understood as a *process* that is inherently social in nature. Individuals and communities in specific localities share and adapt local knowledge, selectively integrate "scientific" knowledge, and develop new and better ways of managing resources, responding to opportunities and overcoming local challenges.
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> (QUNO 2015: 8)

The Quaker United Nations Office, the source of that quote, follows with the important point that 'A broader understanding of innovation in agriculture inspires a reconsideration of the type of policy measures that are needed to nurture and support it' (ibid.). Such reconsideration raises a broad set of policy questions that fall beyond the scope of this article. However, it must surely involve a reassessment of the legal system ostensibly aimed at promoting plant innovation: intellectual property. Are property and monopoly necessarily the answer if the questions are much more diverse and interesting than merely that of how to generate more plant varieties that can generate profit?

There are very good reasons why small-scale farmer innovation should be allowed to persist and not interfered with by inappropriate and monopolistic intellectual property laws and seed regulations including compulsory seed lists like the European Agricultural and Vegetable Common Catalogues. The intellectual property laws may have this effect if they narrow or eliminate the privilege of farmers to replant and exchange saved seed. Seed regulations may do so if they require that the only cultivated varieties sown by farmers be those on an official seed list and that farmers' varieties be mainly or entirely excluded from it for failing to meet strict, inflexible criteria (see Halewood 2016). Unfortunately, in many parts of the world, workable local agricultural systems have been modified and distorted and thereby rendered ineffective. One should not be romantic about traditional agriculture, if for no other reason than that many of these systems have been degraded through no fault of the local people themselves and no longer function as they did. Population increases, the spread of market economies with the introduction of export crops and Green Revolution technologies; all-too-prevalent assumptions that Western techniques and methods such as high-input monocultural agriculture are superior to local ones like intercropping, and the imposition of inappropriate laws and regulations by governments and war are all factors in this.

Nonetheless, original agricultural systems are intact in many areas of the world. Moreover, some good results have been achieved by reviving the use of traditional crop species and introducing modern post-harvesting technologies that ironically can enhance the viability of 'old' varieties and species for the benefit of farmers and consumers (e.g., Cruz 2004). The interaction of traditional knowledge with agricultural techniques applied to local *or exotic* crops is fertile ground for innovation in many parts of the world.

Plant intellectual property

Plants are of course self-reproducing. With no law to prevent it, there is nothing to stop farmers from replanting harvested seed, or even multiplying seed for the purpose of selling it in competition with the breeder (assuming this would be more profitable for them than selling harvested produce). This is where intellectual property rights come in.

To date, the only PVP system with international recognition is the one defined under the International Convention for the Protection of New Varieties of Plants whose contracting parties form an association known in the original French as the *Union pour la Protection des Obtentions Végétales* (UPOV). The UPOV Convention was opened for signature in 1961. The most substantial revisions took place in 1978 and 1991. The drafting of the Convention drew in part on the German Law of June 27, 1953 on the Protection of Varieties and the Seeds of Cultivated Plants, which offered legal protection for 'useful' new varieties that were 'individualised' (read: distinct) and 'stable'. In turn, this law was derived from non-intellectual property seed regulations (Sage 2002). Legally separate but complementary seed regulations continue to exist alongside PVP in many parts of the world, and in some cases these require commercial farmers to use only registered seed.

To be eligible for protection under the UPOV system, plant varieties must be new, distinct, stable and uniform. To be distinct, the variety must be distinguishable by one or more characteristics from any other variety whose existence is a matter of common knowledge anywhere in the world, implicitly including among traditional farming communities. To be considered stable, the variety must remain true to its description after repeated reproduction or propagation. Accordingly, it must have a certain level of uniformity that avoids change in the variety through genetic drift. The uniformity requirement cannot practically be the same for species with different ways of reproduction; self-fertilising species can be much more uniform than cross-fertilising crops. Uniformity requirements are made relative instead, that is, a new variety should be uniform when compared to the varieties of the same species. This means that when the plant-breeding techniques were refined, the uniformity requirement gradually increased, placing it beyond the reach of farmer-breeders who may select in landraces to develop new varieties.

The 1978 version of UPOV, which several countries are still contracting parties to, defines the scope of protection as the breeder's right to authorise the following acts: 'the production for purposes of commercial marketing; the offering for sale; and the marketing of the reproductive or vegetative propagating material, as such, of the variety'. The 1991 version extends the scope of the breeders' rights in two ways. First, it increases the number of acts for which prior authorisation of the breeder is required. These include 'production or reproduction; conditioning for the purpose of propagation; offering for sale; selling or other marketing; exporting; importing; stocking for the above purposes'. Second, such acts are not just in respect of the reproductive or vegetative propagating material, but also encompass harvested material obtained through the use of propagating material, and so-called *essentially derived varieties.*

However, the right of breeders both to use protected varieties as an initial source of variation for the creation of new varieties and to market these varieties without authorisation from the original breeder (the 'breeders' exemption') is upheld in both versions. This represents a major difference with patent law, which normally has a very narrow research exemption (Prifti 2015). At this point, it is worth mentioning that many plant breeders are concerned about the effects of patents on free access to plant genetic resources including varieties bred by others.

There is no reference in the 1978 version to the right of farmers to resow seed harvested from protected varieties for their own use (often referred to as 'farmers' privilege'). The Convention establishes minimum standards such that the breeder's prior authorisation is required for at least the three acts mentioned above. Thus, countries that are members of the 1978 Convention are free to uphold farmers' privilege or eliminate it. All UPOV member countries implemented the exemption for 'private and non-commercial use' under the UPOV Act of 1978 so as to include the re-sowing and in some cases the local exchange or sales of seed. However, this was not the case in ornamental crops in the Netherlands, where a stronger protection was deemed necessary. Conversely, in the United States this was interpreted very widely, resulting in practice in sales of farm-saved seed being allowable to a level where it would contribute less than 50 per cent of total farm income, thus resulting in large quantities of seed being 'brown bagged' to the detriment of the commercial interests of the breeder.

The 1991 version is more specific about this. Whereas the scope of the breeder's right includes production or reproduction and conditioning for the purpose of propagation, governments can use their discretion in deciding whether to uphold the farmers' privilege, which includes only the use of saved seed on the same farm (and thus excludes any type of exchange or sale of such seed). According to Article 15, the breeder's right in relation to a variety may be restricted 'in order to permit farmers to use for propagating purposes, on their own holdings, the product of the harvest which they have obtained by planting [...] the protected variety'. The seed industry generally dislikes the farmers' privilege. Firms prefer fresh purchases for every planting season. However, the 1991 Act states, under Article 15(2), that where UPOV members opt to retain the privilege, they must in some way or other take into account 'the legitimate interests of the breeder'. Implicitly, the European Union, through its Regulation 2100/94 on Community Plant Variety Rights, links this requirement to Article 17(2) of UPOV 1991, so that safeguarding these interests entails ensuring 'that the breeder receives equitable remuneration'. Accordingly, the Regulation restricts farmers' privilege to certain crops, and breeders must be remunerated through the payment of royalties unless they are small farmers, in which case they are exempted. At present the strength of the 'farmers' privilege' varies quite widely. Previously, France had no farmers' privilege at all with the exception of tender wheat, but the country now fully provides the privilege according to the provisions of Council Regulation (EC) No. 2100/94 of 27 July 1994 on Community plant variety rights. Interestingly, the European Community's patent rules also require that farmers' privilege be provided and defined under the same terms as the above Regulation. The United States' PVP rules are less strict in this regard.

Despite some recent reversals, the United States has tended to be the boldest jurisdiction for subject-matter expansiveness. In a 1985 patent appeals case, the Patent and Trademark Office affirmed the patentability of plants, seeds and plant tissue cultures. During the 1980s and 1990s, Europe tended to follow these trends, albeit with some important differences. In the late 1980s, the European Commission decided to draft a directive on the legal protection of biotechnological inventions. The European Commission was motivated by concerns about the legal uncertainties which, it was felt, could be prejudicial to the future of biotechnology in Europe, and fears that some European countries might respond to mounting controversy by banning patents on living organisms and genes. However, it was only in 1998 that the *Directive on the Legal Protection of Biotechnological Inventions* (Biotech Directive) was finally adopted.

The situation in Europe with respect to the patenting of plant-related inventions has been plagued by legal uncertainties, due to the difficult wording of European patent legislation in the face of rapidly changing scientific and business possibilities, concerns about the moral implications of the new biotechnologies and the ambivalence about biotechnological innovation among citizens and some of the governments. The 1973 European Patent Convention (EPC) states in Article 53(b) that patents shall not be granted in respect of 'plant or animal varieties or essentially biological processes for the production of plants or animals'. This did not settle matters completely (see below).

According to Article 3(2) of the Biotech Directive, 'biological material which is isolated from its natural environment or produced by means of a technical process may be the subject of an invention even if it previously occurred in nature'. As with the Convention, animal and plant varieties and essentially biological processes for the production of plants and animals are excepted (for more discussion on the meaning and scope of this – see below). Article 2.2 clarifies that 'a process for the production of plants or animals is essentially biological if it consists entirely of natural phenomena such as crossing or selection'. This definition has been accepted by the European Patent Office (EPO). In recent years, though, it has proved to be a complex issue. This is hardly surprising when we consider that classical plant breeding nowadays is often assisted by biotechnological methods. Where the production of a new plant stems from a method comprising a mix of both, at what point does the whole process cease to be essentially biological?

Patent protection for plants and plant parts was introduced just as agricultural biotechnology emerged. Soon after the technique of recombinant DNA was invented the possibility of transforming plants through the introduction of 'foreign' genes became evident to plant scientists. Perhaps the most important technique relies on the use of *Agrobacterium tumefaciens*, a common plant-infecting bacterium, to insert genes into plants thereby modifying these plants with new traits, such as pest and herbicide resistance. This technology was complex enough to be covered by more than one patent. Other molecular biological methods have been developed to improve plants with greater precision and speed than classical plant breeding methods alone, and by enabling the exploitation of a radically expanded genetic resource-input base. Valuable traits can be characterised, inserted and expressed more easily than ever before. For proponents, this makes biotechnology more accurate and rapid, though critics claim that these advantages can, to some extent at least, be challenged on scientific grounds. Moreover, they enable the possibility of incorporating traits not just from the same species of plant or from a wild or semi-domesticated relative, but from a virtually limitless array of life forms including bacteria and viruses. The potential resource base is thus no longer just earlier varieties of the same or related species, but life in its broadest sense.

None of this replaces classical plant breeding based on crossing and selection. It is still needed. Once you have genetically modified a crop you still need to breed varieties that farmers want to grow under conditions varying from place to place and farm to farm. This is evident from the fact that many PVP certificates in the United States, where genetically modified crops are of course widely cultivated, are held by companies like Monsanto. For example, soybean variety A1026742 was granted PVP certification in April 2013. Provided in the documentation submitted to the Plant Variety Protection Office is a notification that the 'technology' in the plant is covered under nine patents. Those patents claim the transformation techniques, the added genetic elements and the plant and plant parts containing them. The variety itself is also the subject of a separate patent application. That is quite a weighty bundle of rights around a single plant variety. Molecular biology including genomics can assist breeders in ways enabling them to accelerate their work but without eliminating the need for the classical techniques they have always employed.

Agricultural biotechnology especially genetic modification involving the incorporation into plant genomes of foreign DNA is a hugely controversial issue. Genetically modified seeds provide numerous benefits for many farmers. But there is no certainty that the gains are sustainable in the longer term. Also, these crops come at a huge cost and not just in the monetary sense. The steady erosion of farmer autonomy under the iron grip of a small number of large monopolistic corporations using, at least in Monsanto's case, the full panoply of contract law, intellectual property protection and corporate-friendly regulation in Canada and the United States (albeit still not in Europe) is changing the practice of agricultural production in far-reaching ways that alarm many people.

In North America, buying Monsanto's seed is a bit like buying software with the main exception being that whereas Microsoft has no legal right to routinely inspect all of its customers' homes, Monsanto is authorised by contract to carry out such checks on any seed buyers' farms. You can use it but you'd better not copy it after the initial multiplication of the first harvest. In a sense, farmers are not really buying anything at all since their possession of the seed they purchase is incomplete. All they have are certain limited usage rights. Accordingly, saving harvested seeds to plant on the farm, a practice going back to the earliest days of agriculture, is simply not tolerated. Seeds found on one's farm containing Monsanto's patented genes are Monsanto's not the farmer's, regardless of how the seed containing them got there. Monsanto has been able effectively to separate ownership from legal liability.

Thus, through intellectual property rights, the law of contract and court judgments, Monsanto wields a great deal of power over farmers. Two high-profile patent cases in North America, both having Monsanto as a party, are illustrative of this.

In 2013, the United States Supreme Court by a unanimous decision upheld Monsanto's claims that a farmer named Vernon Bowman had infringed two patents claiming aspects and embodiments of its Roundup Ready technology including seed (*Bowman v Monsanto Co.* 569 US 2013). Bowman had been acquiring and planting Monsanto beans legally over several years. However, he also separately acquired Monsanto beans from a grain elevator for a late-season planting. Grain elevators are facilities to which farmers typically sell much of their seed. His motivation for doing so was that late-season plantings are more risky in terms of yields, therefore his preference was to evade the normal premium pricing for authorised Monsanto beans, which are patented *and* whose use is subject to the company's usual stipulations. Since Monsanto is a virtual monopolist in the vicinity, it was obvious that the commodity beans acquired from the grain elevator would almost entirely be Roundup Ready. Bowman retained seed and replanted it for the following year's late-season planting and continued this practice in subsequent years.

He justified his actions with the defence that without Monsanto's licensing terms being applicable, Bowman's freedom to do what he wished with the purchased seed extended to harvested seed from plants grown from it. The rights of patent owners are exhausted upon first sale. It followed, the argument ran, that farmers have full freedom to do as they wish with plant material descended from legally acquired seed, and patent owners have no rights to interfere with this. From Bowman's perspective, he had therefore done nothing wrong. The seed was legally purchased and this was not in dispute. He had planted the beans so acquired as farmers do. Nature does the rest and that is no longer any of Monsanto's business.

The Court dismissed Bowman's 'blame-the-bean defence': that beans have the capacity independent of humans to germinate and develop new plants, therefore he did not make the bean-yielding plants from the beans he planted. The Court acknowledged that he had the right to consume or resell the acquired seed. What he could not do with it was to use it to make more seed. Why? Because in doing so he was 'making' the invention and doing so without the authorisation of the patent holder. Two questions arise. First, is planting equivalent to making? Second, if it is, why is this making an infringement? According to the dictionary, planting *is* making and for the Supreme Court this was good enough. It was infringing because it denied Monsanto a benefit that the patent system is supposed to provide to inventors.

One angle of the case that attracted wider attention was the self-replicating nature of the invented object. Seed when it lands, or is placed, in the ground under suitable conditions 'makes' multiple copies of itself and each of those copies will in turn make even more. This is a fact of biology. However, on the farm there is a certain artificiality to what goes on. Farmers will seek to optimise those 'suitable conditions' by, for example, removing competing plants, tilling the soil, watering and applying chemicals to protect them. They also plant the seeds in locations they deem to be appropriate. Farmers intervene in nature in such ways, but nature undeniably 'rules'. Be that as it may, Bowman's actions were 'making' even if they did not amount to manufacturing as the word is commonly understood. The decision was founded on conventional reward and incentive-to-innovate justifications for patents.

Another well-known case, albeit from another jurisdiction, that appears to expand the scope of infringing behaviour in rather controversial ways is the Canada Supreme Court's decision in Schmeiser (*Monsanto Canada Inc. v Schmeiser*, [2004] SCC 34). Monsanto's patent concerning Roundup Ready canola covered genes, plant cells and expression and transformation vectors *but not the plants themselves.* By the time the dispute reached the Supreme Court, plants *per se*, being higher life forms, were not patentable anyway. In 1996 Percy Schmeiser, a farmer in Saskatchewan province, planted canola seed on a 370-acre field and replanted some of the harvested seed. He sprayed a small three-acre strip of land by the road with Roundup and 60 per cent of the canola present survived. He harvested the seeds and set them aside for storage. Monsanto checked by the roadside boundaries of his lands and found the plants there to be Roundup Ready and subsequently warned him. Schmeiser went ahead anyway and after getting the saved seed cleaned, he planted it on several fields covering 1000 acres in total area. In 1998, Schmeiser was found to have at least 95 per cent of his harvest to be Roundup Ready. This was despite the fact that he had never purchased Monsanto's glyphosate-resistant seed. Indeed, there was no conclusive explanation for its appearance on his farm. As to its abundance, this is a difficult matter. The Court did not discount the possibility of its derivation from seed harvested the year before from that small patch of roadside land, though the trial judge had been sceptical to say the least. As mentioned, he had sprayed that area with Roundup, so the survival of these canola specimens obviously proved they were Roundup Ready, and he stored these seeds rather than sold them.

Had Schmeiser 'made' the invention? The Court was not persuaded that he had made the claimed genes, cells or vectors. In other words, by planting and cultivating seed he had not made these things contained in the resultant plants. What about use? On the basis of dictionary definitions and established principles of statutory interpretation, the majority concluded that he had. In the present context, and following a line of case law, 'use' of an invention was taken to mean utilisation with a view to production or advantage, and infringement is established where commercial activity involves use of a thing of which the patented part is a component. By a purposive construction of claims, the Court surmised, a persons skilled in the art would have interpreted what was claimed in the patent to include use of those plants that were regenerated from the patented cells. There is no need to prove use of the isolated elements. Consequently, the Court held that there was infringement.

But had Schmeiser interfered with Monsanto's enjoyment of its legal monopoly, or actually taken advantage of the genetically modified characteristics of the seed for which Monsanto was responsible? Schmeiser's motives and actions are somewhat opaque. He denied that he had used Roundup herbicide. If we accept his testimony, surely he did not use Monsanto's invention because without applying Roundup it was not performing its function of protecting plants from glyphosate herbicide. And if the seeds he planted were no more useful to him than the closest non-GM alternatives, it is hard to see how his actions had much impact upon Monsanto's enjoyment of its patent monopoly. The Court faced this issue head-on defending its finding on the basis that the properties of Roundup Ready had 'stand-by or insurance utility', that is, that the option was there to spray with glyphosate in case of future necessity even if the farmer was choosing ordinarily not to do so.

Europe has a difficulty that the United States does not have. This is that since the early 1960s, European countries took the decision to keep out of the patent system conventional plant breeding, both the methods of crossing and selection and the plant varieties so developed. Legally, this was perfectly straightforward until the arrival of genetic transformation technologies. With genetic engineering, the plants so transformed, not being explicitly excluded, were deemed to be inherently patentable, at first. In 1988, the EPO began to grant patents on plants.

But at some point, this was bound to lead to problems given the exclusion of plant *varieties* in favour of national UPOV-compliant PVP systems. The line of demarcation between plants and plant varieties is a source of difficulty not least because PVP and patents are not natural bedfellows. However, in December 1999, the EPO Enlarged Board of Appeal decided that, while 'plant varieties containing genes introduced into an ancestral plant by recombinant gene technology are excluded from patentability', 'a claim wherein specific plant varieties are not individually claimed is not excluded from patentability under Article 53(b), EPC even though it may embrace plant varieties' (*see* EPO Decision G 01/98 Transgenic Plant/NOVARTIS II).

Let us briefly return to the essentially biological processes exclusion. It is an odd turn of phrase really and raises questions again about where to place the natural/artificial boundary and whether the law is consistent or logical about it. It is implicitly accepted for the sake of convenience that classical plant breeding is so beholden to underlying biological phenomena that what breeders do is biological. But what if the plant production process comprises steps other than 'mere' crossing and selection, that is to say, it is a mix of biological and non-biological elements? And what if the process works for any plant variety other than one or a few named ones, that is, that plants are claimed at a higher taxonomic level than the variety?

The answer to the first question is 'it depends'. It matters whether the technical interventions enable or assist the crossing and selecting activities, or whether the interventions introduce or modify a genomic trait. The latter process, overcoming concerns about unrepeatability, and lack of inventiveness including technical character, will escape the exclusion (*see* G-2/07 Broccoli/PLANT BIOSCIENCE II).

Regarding the second question, in 2015 the Enlarged Board of Appeal ruled that plants or plant material are not excluded merely because the method of producing them was essentially biological, including when it is the only method available on the filing date. Moreover, in the circumstances of the case, and arguably as a consequence of the EPO's pro-patent bias (Girard 2015), product-by-process claims were deemed as permissible even when the process is an essentially biological one (*see* G2/12 Tomatoes/STATE OF ISRAEL-MINISTRY OF AGRICULTURE II; G2/13 Broccoli/PLANT BIOSCIENCE). However, in 2016, the European Commission issued a note expressing the view that no plant or animal plant materials (varieties or otherwise) are patentable if obtained through essentially biological processes involving no non-biological, including microbiological, steps (European Commission 2016).[2] In June 2017, the Administrative Council of the EPO decided to take this Commission Notice into account and amend the regulations accordingly.

Does plant innovation need intellectual property?

Seed companies tend, understandably, to be favourably disposed towards intellectual property rights. Whether or not they are pro-patent, they are likely to favour PVP. This is hardly surprising given that they are the intended beneficiaries. Bringing scientific expertise into the enterprise of crop improvement must surely in itself be a good thing. Intellectual property rights are assumed to encourage this. If intellectual property *does* work this way, it improves the supply of high-yielding varieties for farmers. It appears to incentivise *overall* investment in commercial crop breeding, and so can compensate for reduced government spending on public sector crop research. It also creates a market for foreign and domestic breeding material through the possibility to license.

However, the news is not all good, and that is an understatement. Not all of the following problems can be laid at the door of intellectual property rights, as the issues raised are systemic ones that implicate not just intellectual property rights but seem to be inherent to modern agriculture.

First, the supply of scientifically bred seeds forms part of a package of inputs that can be expensive and lead to debt dependency. The experience of many developing farmers who were caught up in the Green Revolution of the 1950s and 1960s and have since then continued to depend solely on so-called modern varieties seems to bear this out.

Second, exposure to seed-chemical input packages decreases the relevance of local farmer knowledge and expertise. Once local knowledge and expertise are no longer used, they are forgotten though for all we know their relevance may at some future time increase again. But they will of course no longer be available.

Third, modernisation of agriculture tends to be associated with the cultivation over large areas of only a few genetically uniform varieties and crop species. Monocultural production can increase risk and impacts of pest and plant disease outbreaks. Intellectual property rights tend to encourage investment in crop improvement targeted to a relatively small number of crop species. Moreover, as Rangnekar (2000a, 2000b) showed many years ago, in part as a consequence of the broad research exemption permitted under PVP rules, breeders tend to recycle for crossing existing varieties already in wide circulation among the scientific breeder community. These of course tend to be genetically quite uniform. Thus intellectual property rules, as with seed regulations, tend to fall short in terms of encouraging genetic heterogeneity.

Fourth, concerns have been raised as to whether scientific breeders encounter an inherent trade-off in the sense that the objectives of higher yields and convenience for farmers can lead to breeders selecting and breeding crops with lower nutritional quality. This situation has been referred to as 'the breeder's dilemma' (Morris and Sands 2006).

Fifth, the increased use of intellectual property rights, contracts and the application of restrictive seed regulations can reduce farmer independence and autonomy. Seed licensing agreements effectively turn seed 'sale' into a highly restrictive transaction where money is exchanged not for the full possession of seed – as with the sale of most other types of good – but for a limited set of usage rights whereby seed is deemed legally to be a technology, or the container for a technology, whose ownership is retained by the intellectual property owner.

Finally, intellectual property rights generally do not incentivise investment in domestic staple food crops with small-value markets, even those crucial for food security hence the issue of neglected or orphan crops. Therefore, incentives may not be socially optimal. UPOV statistics show clear evidence of developed country-based seed companies becoming more interested in developing country markets, sometimes taking over domestic firms (as in Argentina), or using foreign territories for producing their plants for exportation. Often such plants are ornamentals or out of season vegetables for the European and North American markets. For example, out of 482 PVP applications in Kenya from 1997 to 2003, 247 were for roses, all of which were foreign bred (UPOV 2005: 55). Rangnekar adds some additional information concerning applications and grants for that country: 'by 2004, just over 45 per cent of the PBRs [i.e. PVP] applications were for flowers and vegetables. And, foreign breeders dominate by accounting for 57 per cent of the applications and 79 per cent of the grants' (Rangnekar 2014). Whether foreign applicants are shifting breeding operations to developing countries in order to adapt their varieties to local conditions, which might be a very good thing for these countries, cannot be revealed by these statistics alone. For developing countries, which are more likely than developed countries to have a big shortfall in resident applications as compared to non-resident ones, such additional costs may be quite burdensome. This matter does require case-by-case analysis: much depends on the kinds of plant for which foreign applications are most common. Even if those developing countries with an established domestic private sector experience a growth in investment thanks to PVP, public sector breeding is still likely to be of vital importance. It is not a realistic or sensible policy to depend on the private sector to do all the work. Public sector crop improvement is the norm in most parts of the world. While private investment may be useful in making up for cuts in government spending on crop improvement programmes, it does not automatically make sense for public breeders to be kept away from commercially oriented breeding as a matter of policy. There is no guarantee that the private sector will step into the breach to take advantage of the elimination of public sector competition even with the availability of PVP.

According to an FAO report published in 2009,

> the combination of industrialization of agriculture and formal training for plant breeders created a gap between breeders and farmers, a gap that was exported to developing countries in the post-war era. As the profession of plant breeding lost the habit of interacting closely with producers, concern for how to address farmers' needs and constraints fell by the wayside […] Today there is widespread recognition that the conventional package of new varieties and external inputs, while successful in the more favourable production areas, has often failed to benefit small-scale farmers in marginal areas.
>
> (Ceccarelli et al. 2009: vii)

Of course, not all of the fault can be laid at the door of intellectual property rights. However, patent and PVP are doing little to reverse this tendency to focus on large-scale industrial agriculture and a narrow range of crops. As the Global Panel on Agriculture and Food Systems for Nutrition (2016: 88, internal references omitted) observed recently,

> the Consortium of International Agricultural Research Centers (CGIAR), which commands the most significant capacity to conduct agricultural R&D in low- and medium-income countries, still allocates about half of its resources to rice and maize. In the private sector, about 45% of research investment is directed towards just one crop: maize.

Thus, we see an imbalance in investment, scientific endeavour and commercial activity which intellectual property rights seem to exacerbate or at least fail to shift in a more positive direction from the perspective of small-scale farmers.

Conclusion

To say that PVP and patents are essential to providing the necessary incentives for innovation is to assume that plant innovation *only* takes place off farm by scientific breeders and biotechnologists, *and* that the private sector alone is responsible. That would be to deny the existence of innovation from two other important sources: the public sector and farmers. The role of farmers in both plant innovation and maintenance of agricultural biodiversity continues especially to be underappreciated. Putting small-scale farmers first is easier said than done. What we can say is that without a better understanding of the social nature of innovation, the cultural and spiritual values prevailing in their societies, the customary norms relating to scarce resources and the material needs of the farmers and their communities, we are most likely to impose another set of top-down and inappropriate policies and laws. It is unlikely that many small-scale farmers in developing countries would be more motivated to innovate by the possibility of being able to claim legal monopoly rights. Moreover, given the concerns raised in this article there are other reasons to push against intellectual property as a one size fits all solution. Well-designed and culturally appropriate commons approaches might just point to a better future.

Notes

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2 It is noteworthy that in accordance with the Law for the Recovery of Biodiversity, Nature and Landscape of August 8, 2016, the French Intellectual Property Code now states that '[P]roducts exclusively obtained by the essentially biological processes […], including the elements constituting these products and the genetic information contained therein' shall not be patentable.

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