Published in final edited form as:

Nat Biotechnol. 2013 January ; 31(1): 25–29. doi:10.1038/nbt.2467.

The evolving landscape of plant varietal rights in the United States, 1930–2008

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Intellectual property protection for plant varieties seems perpetually embroiled in policy controversy and professional debate. The United States, a hub of plant innovation with multiple types of plant IP protections, has long been at the center of the storm. As early as 1869, the objections of a writer in the *Rural New Yorker* captured the essential argument that persists to this day:

“As a horticulturalist I protest the movement and hope Congress pays no attention to the matter. The originators of valuable varieties have it in their power now to secure ample compensation: and it is their own fault if they do not....In my opinion, the influence of a patent law of this kind would be to retard the dissemination of new things and in this way be a positive damage to the country....For these and many other reasons I am in favor of letting this matter regulate itself, as it does at present...”¹

His wish, of course, was ultimately denied: Congress saw fit to extend the protections of patent law to plants and other living organisms, and has been refining and expanding the purview of those protections ever since. The flames are fanned again as the Leahy-Smith America Invents Act of 2011 has begun to reshape elements of US patent law.

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The types of plants being protected, by whom, and by what form of varietal right has changed markedly since the United States first enabled intellectual property protection for plant varieties in 1930.

A brief legal history

Though the debate over IP protections for plants took off with the work of Darwin and Mendel in the late 1800s, it was not until 1930 that President Herbert Hoover signed the Plant Patent Act into law. Plant patents, granted by the US Patent and Trademark Office, cover asexually reproduced plants, a category that largely encompasses ornamental plants and fruits. Unlike the utility patents that cover most inventions in the US, plant patents require no yearly maintenance fee to remain in effect. In a 1998 update to the law, patentees are able to exclude others from importing any part of a protected plant.

Sexually reproduced crops, a category that includes grains, oilseed crops and grasses, gained IP protection in 1970 under the Plant Variety Protection Act. Plant variety protection (PVP) certificates are administered by the US Department of Agriculture, and they are weaker than a plant or utility patent in two important ways. A “breeders’ exemption” allows others to use protected varieties for breeding, though not for commercialization². And a “farmers’ exemption” allows farmers to save seed for reproductive purposes and even to resell it to other farmers whose primary occupation is growing crops for consumption or feed³.

A third form of protection became possible in 1980 with *Diamond vs. Chakrabarty*, in which the US Supreme Court narrowly found that “anything under the sun that is made by man” is patentable subject matter⁴. In practice, this case and subsequent legal rulings clarified that plant varieties, parts of plants, genetically engineered organisms and gene products themselves were eligible for the same US utility patents that cover most other inventions. In 2001, the Supreme Court further clarified that plants covered by a plant patent or PVP certificate could obtain utility patent protection as well. A chronology of key legislative and legal events related to IP protection of plant varieties in the US can be seen in Supplementary Table 1. Notably, in the US it is possible to get dual protection for plant varieties via a utility and a plant patent, or a PVP certificate and a utility patent, but not via a PVP certificate and a plant patent. This issue was legally resolved in 2001 by a ruling that affirmed the legality of dual protection for plants⁵. Protecting plant varieties by utility patents is rare worldwide: the US, Australia and South Korea are among the few countries that explicitly allow it. While Canada does not explicitly allow utility patents on plant varieties, the Canadian Supreme Court upheld a finding of infringement of a plant containing a patent-protected DNA sequence⁶.

The legal landscape will continue to be shaped by court rulings and the growing practice of contractual licensing arrangements between patent-holders and customers, which in many cases impose additional restrictions beyond IP protections. Trade negotiations over IP continue to shift the international landscape, and new legislation creates changes in the US. The Leahy-Smith America Invents Act, passed late in 2011, makes it easier to challenge patents, expands the categories of prior art, and changes the US to a “first to file” regime for all patents, including plant patents and all utility patents applying to plants.

Varietal rights since 1930

The policy and practical concerns that arise from enabling property rights to plant varieties are myriad. Some analysts and commentators suggest that varietal rights restrain access to

germplasm, which in turn slows the pace of crop varietal innovation⁷. Corollaries include the assertions that varietal rights decrease R&D spillovers; that they shift the balance of innovation from freely accessible, public sources to private, profit-making ones; and that these processes undercut the welfare of developing countries and subsistence farmers^{8–10}. Others find little evidence that plant varietal protection works as intended, stimulating the rate of innovation or crop productivity growth^{11,12}. To even begin to assess these purported effects requires some concrete evidence on the types of plants being protected, by whom, by what instrument, and how these rights have evolved over time.

The number of varietal rights has generally increased over time (Fig. 1), with 42 percent of all grants/applications lodged since the year 2000 (an average of 1,600 per year since 2000, compared with just 41 applications in the first decade of our time series; see Supplementary Methods). Plant patents (PP) are the most prevalent type applied for among the three; their growth was not slowed—and in fact accelerated—after utility patents (UP) began to be granted in the 1980s for plants. While UPs initially grew slowly, in recent years the rate of utility patenting has generally outpaced the rate of plant variety protection (PVP) applications. Annual UP volumes were greater than PVPs in most years since 2006.

As one would expect given the subject matter restrictions of each type of varietal right, none of the (sexually reproduced) cereal or oilseed varieties is protected by a plant patent. A much more diverse set of crop classes are subject to plant variety protection, including cereals (29 percent), oilseeds (20 percent), vegetables (20 percent), grasses (12 percent), and fiber crops (6 percent). Supplementary Table 2 provides a more detailed breakdown of the rights by category of plant. While all plant types are eligible for utility patents, two specific cereal crops dominate this type of protection: corn varieties constituted 46 percent of the 3,719 utility patents granted from 1982 to 2008 and soybeans accounted for 38 percent of the total. Vegetables made up a smaller but notable share (5 percent), with less than 2 percent of the utility patents protecting ornamental, fruit, and tree crops.

The structure of rights has changed considerably over time. During the 1950s, before PVPs and utility patents were granted, ornamentals and fruits accounted for 95 percent of the rights issued, with ornamentals alone accounting for 76 percent of the total (Fig. 2a). Fifty years later, specialty horticultural crops were still the dominant type of plants being protected, but they constituted a much reduced share of the rights granted (63 percent of the total, with ornamentals accounting for 52 percent). Looking at the structure of varietal rights, by crop, across the three types of protection, ornamentals and fruits account for 96 percent of the plant patents, while 87 percent of the utility patent protection—which can be extended to all types of plants—pertains to cereals and oilseeds (Fig. 2b).

Diving more deeply into specific plant-types, rose varieties account for the largest share of all varietal rights issued over the entire 1930–2008 period. But roses have lost some ground, slipping to the third-ranked crop during the last five years of our sample. Notwithstanding the continued dominance of horticultural crops as a category, corn and soybean varieties are now the top two ranked crops overall. They accounted for around one-third of all PVP applications in the 2004–2008 period and account for more than 80 percent of the pool of

utility patents granted. Cotton ranked third in terms of utility patents and fifth in terms of PVP applications.

The crop concentration varies markedly among the types of rights. While corn and soybeans accounted for much more than half the utility patents granted during the period 2004–2008, it took four crops (soybean, corn, wheat and turf grasses) to reach a 50 percent market share for PVPs during this same period, and 10 crops to account for half the plant patents.

The pool of applicants seeking varietal protection has also changed substantially over the years (Fig. 3). The share of grants and applications from individuals has dwindled, while the share from the corporate sector (foreign and domestic companies) has risen dramatically. During the 1930s and 1940s, private companies accounted for about 55 percent of the rights; during the last five years of our time series, private companies accounted for 82 percent of the total rights. While the rate of growth in grants and applications from US individuals inched up over the years (an average of 20 rights per year in the 1930s versus 91 rights per year in the 2000s), these applicants now constitute just 4 percent of all varietal rights. This change in the structure of IP activity most likely reflects more fundamental changes in the structure and cost of doing and paying for research, and equally if not more importantly, marketing new seed and crop varieties^{10,13}. Notably, UPs have always been dominated by (predominantly US) companies (Fig. 3b). PVP applications were also mainly sought by companies.

The share of foreign entities (the vast majority of which are companies) has risen dramatically and consistently in recent decades (largely accounting for the share lost by US individuals). In contrast, while the patent volume accounted for by US companies has been somewhat volatile, its long run share has oscillated around 60 percent (until the last decade, when it ceded more of its share to foreign applicants). Before 1982, foreign companies accounted for about 10 percent of varietal rights in the United States; since 2001, their share has been consistently in the 30 to 40 percent range. As Figure 3b shows, much of the gain in foreign volume has come in the form of PPs. The inflation-adjusted value of floriculture and nursery imports (including cut flowers, nursery stock and bulbs) increased six-fold from 1976 to 2006 (ref. 14), so it should be no surprise that foreign entities accounted for 64 percent of all the plant patent rights in the US in 2008 (compared with 21 percent in 1984). We estimate (in data not shown here) that 62 percent of the foreign plant patent rights in 2008 came from just four countries—the Netherlands, Germany, United Kingdom and Japan.

Another notable trend evident from Figure 3 might more accurately be described as the lack of one: despite the high volume of research performed at US and foreign universities, research foundations and government agencies, such public entities still account for only a small share of varietal rights. US universities are represented in Figure 3, as they accounted for the lion's share of all publicly sourced PVP applications and patent grants in recent years. In 2008, universities comprised just 5.6 percent of the 1,882 total applications and grants that year—even less than the number lodged by individuals.

Has concentration increased, in any general sense? The data as presented in Figure 4 suggest that it has, though a certain degree of concentration has been present from the start. Figure 4 plots the cumulative share of varietal right applications for each of the three types of rights on offer against the cumulative number of applicants arrayed from left (largest) to right (smallest) in terms of the total number of applications lodged per applicant (other than individuals) during the 1930–2008 period. Curves more strongly “bowed” to the upper left-hand corner of the figure indicate more concentrated holding of rights; flatter curves indicate a more even distribution of applications among applicants. PPs have been, and remain, quite dispersed, with half the total pool of applications spread among 79 entities. In contrast, just two applicants (Pioneer Hi-Bred and Monsanto) account for nearly half the UPs, and 22 applicants were needed to account for half the PVP applications¹⁰. These data are reported according to the entity applying for or granted the right; it does not account for subsequent changes in the status (merged, divested or otherwise) of entities over time. All three types have seen an increase in concentration. As companies within the US seed sector in particular and plant innovation markets more generally have consolidated¹⁵ so too has the pool of applicants for varietal rights.

Table 1 gives a granular look at the dominant entities for each type of protection, over the most recent years of our time series. It underscores the changing institutional complexity of these evolving IP markets. Listed are the top 10 applicants for each of the three forms of varietal rights on offer, plus the top 10 applicants for plant varietal rights irrespective of the type of right. These details reveal a major institutional dichotomy between the agencies most active in the UP and PVP segments of this market and those with a major stake in the PP segment. Only one company (Syngenta) that shows up in the top 10 list for PPs also appears in the top 10 list for the other forms of protection. In contrast, four companies are cross-listed among the top 10 for PVPs and UPs. This suggests that the technical (e.g., breeding and multiplication) and marketing requirements for the vegetatively propagated (mainly ornamental) crops are distinct from the sexually reproduced crops that constitute most of the utility and (all the) PVP claims. Apparently, there are less compelling scientific or commercial rationales for integrating operations among sexually and asexually reproduced crops (at least to this point in time). The relative extent of concentration reflected in Figure 4 is quantified in the ‘top 10’ and ‘top 20’ shares given near the bottom of Table 1. For UPs, the top 10 patent grantees comprise 89 percent of rights; for PVPs, 55 percent; and for PPs, just 27 percent.

Conclusions

When plant varietal rights were first offered in the United States in 1930, the agriculture sector, including horticulture, produced \$10.2 billion worth of output; there were 6.5 million farms, averaging 151 acres per farm. Almost 80 years later, the US agricultural economy has grown 24-fold, yet the farm sector has massively consolidated, down to 2.1 million farms averaging 446 acres in size. Moreover, 70 percent of the agricultural production (by value) came from just seven percent of all commercial farms in the United States in 2003 (ref. 16).

Across the board, US farms are less reliant on farm-produced inputs. Farm-produced power, mainly horses and mules for traction, has given way to off-farm traction and energy sources.

A substantial share of animal feeds is now grown off the farms where they are used, and purchased chemicals (herbicides, pesticides and fertilizer) have grown as a share of the total cost of farm production. Notably, and of particular relevance for this paper, significant amounts of seed are now purchased annually rather than saved and reused.

Thus the seed and other input markets servicing US agriculture have evolved and adjusted accordingly. The scientific basis for manipulating cultivated crops has also changed radically over the past 80 years, again changing the incentives and structures of the crop breeding, multiplication and marketing sectors. Along with these broader market changes have come changes in the US markets for intellectual property generally, and for IP pertaining to plant varieties in particular. In this paper we described the changing legislative and legal structures that directly affect plant varieties, as well as the marked changes in the crop, applicant and types of varietal rights being sought since 1930.

Benchmarking these evolving IP rights provides a basis for beginning to understand the complex interplay between the legal, scientific and market forces that have shaped these varietal rights in the US. A better understanding of these IP markets can guide the policy and practice of varietal rights in the US. It can also inform the international dimensions of these markets, which are increasingly intertwined by way of international treaties and global trade.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

The authors are especially appreciative of the research assistance of Chris Pratt, Sydney Pardey, Michelle Hallaway and Connie Chan-Kang and for the excellent assistance with data queries from personnel at the USPTO and PVPO. The research for this paper was supported by the International Science and Technology Policy (InSTePP) center at the University of Minnesota, the University of Waterloo, the National Institutes of Health, and the Bill and Melinda Gates Foundation by way of the HarvestChoice project.

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Figure 1.

US varietal rights, 1930–2008. *Source:* Compiled by authors based on data obtained from USDA-Germplasm Resources Information Network (various years, <http://www.ars-grin.gov/cgi-bin/npgs/html/pvplist.pl>) for PVP certificates, and USPTO (June 2009 and various earlier years for on-line database queries, <http://patft.uspto.gov/>) and Thomson Innovation for plant and utility patents (<http://info.thomsoninnovation.com/>).

Notes: PVP indicates plant variety protection certificates. All data are reported by the year of application. The PVP series represents the number of certificate applications, while the utility and plant patents are the number of granted patents.

Panel a: *Shares of all varietal rights by crop category, 1950-2008*Panel b: *Crop composition by type of right, 2000-2008***Figure 2.**

Changing composition of varietal rights by crop, 1930–2008. *Source:* See Figure 1 and Table 1.

Panel a: *Applicant type, all varietal rights* Panel b: *Applicant type by type of right* **Figure 3.**

Changing composition of applicants, 1930–2008. *Source:* See Figure 1 and Table 1.

Notes: Applications by US government (**a and b**), and by individuals for plant variety protection or by foreign entities for utility patents (**b**) are omitted due to comparatively low counts. While we made a substantial effort to standardize applicant names for rights spanning the same entity (company) filing from different countries, we did not adjust the original location of the filing entity. For example, while the rights sought by Bayer CropScience AG are reported as foreign applications (Germany), those sought by Bayer

CropScience LP are reported as US companies. However, both cases are treated as a single applicant “Bayer CropScience.”

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Figure 4.

Increasing concentration of varietal rights applications, 1930–2008. *Source:* See Figure 1 and **Table 2**.

Notes: Plots represent cumulative share of each form of protection held by each applicant in each period, arranged by descending order of the size of each firms varietal rights holdings.

Table 1

Top ten applicants by varietal rights, 2004–2008

Plant patent			Plant variety protection			Utility patent			All IP		
Applicant name	Number	Share	Applicant name	Number	Share	Applicant name	Number	Share	Applicant name	Number	Share
	count	percent		count	percent		count	percent		count	percent
Yoder Brothers	239	4.5	Pioneer Hi-Bred International	360	19.3	Monsanto	558	31.2	Pioneer Hi-Bred International	876	9.8
Syngenta	228	4.3	Monsanto	196	10.5	Pioneer Hi-Bred International	516	28.8	Monsanto	754	8.4
Goldsmith Seeds	182	3.4	Seminis Vegetable Seeds	108	5.8	Stine Seed Farm	172	9.6	Syngenta	466	5.2
Ball Horticultural Co.	164	3.1	Syngenta	104	5.6	Syngenta	134	7.5	Yoder Brothers	239	2.7
Suntory	157	2.9	D&PL Co.	50	2.7	Mertec	73	4.1	Goldsmith Seeds	182	2.0
Klemm & Sohn	128	2.4	Pure Seed Testing	49	2.6	D&PL Co.	59	3.3	Ball Horticultural Co.	176	2.0
Terra Nova Nurseries	115	2.2	Bayer CropScience	43	2.3	Shamrock Seed Co.	25	1.4	Stine Seed Farm	172	1.9
Poulsen Roser	103	1.9	Rutgers University	43	2.3	Seminis Vegetable Seeds	23	1.3	Suntory	157	1.7
Danziger – “Dan” Flower Farm	72	1.4	WestBred	42	2.3	Bayer CropScience	16	0.9	Seminis Vegetable Seeds	131	1.5
CP Delaware	71	1.3	North Dakota State University	34	1.8	Dow Agrosiences	15	0.8	Klemm & Sohn	128	1.4
Top 10 applicants	1,459	27.4		1,029	55.2		1,591	88.9		3,281	36.5
Top 20 applicants	2,026	38.1		1,228	65.9		1,668	93.2		4,103	45.7
All applicants	5,324	100.0		1,864	100.0		1,789	100.0		8,977	100.0

Source: See Figure 1 and Supplementary Material.

Notes: Data represent count and share of each type of right held by granted applicant. Consolidation of holdings due to subsequent merger and acquisition activity (e.g., Monsanto's acquisition of Seminis in 2005) or divestitures are not reflected in this compilation.