Has the Plant Variety Protection Act achieved its legislative intent?[1]

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ABSTRACT

The Plant Variety Protection Act (PVPA), enacted in 1970, provides patent-like protection for distinctly new plant cultivars reproduced by seed. The primary rationale for the Act was to stimulate plant breeding research, particularly in the private sector. This article examines the extent to which PVPA has achieved its legislative intent. Soybean [*Glycine max* (L.) Merr.] plant breeding activities have increased sharply since PVPA. While premature to evaluate, there has been little apparent effect on the breeding of other crops.

Additional index words: **Research and development, Seed industry, Regulation, Plant breeding.**

THE stated intent of the Plant Variety Protection Act (PVPA) is

> to encourage the development of novel varieties of sexually reproduced plants and to make them available to the public, providing protection available to those who breed, develop or discover them, and thereby promoting progress in agriculture in the public interest (Preamble to Plant Variety Protection Act, 1970).

The increased investments in private plant breeding research was also expected to encourage public plant breeding institutions to allocate more funds to basic research and to areas which industry might not pursue (Committee on Agriculture, 1980). In 1980, the Act was amended. At hearings held by both Senate and House subcommittees, two major issues emerged. First, is the intent of the Act being realized; that is, has the PVPA stimulated increased breeding efforts and resulted in increased numbers of improved cultivars? Second, has PVPA "encouraged unintended trends and activities affecting the agricultural economy, namely, increasing concentration in the seed industry, loss of genetic diversity, and rapid increases in the price of seed?" (Senate Agriculture Committee, 1980). This article examines the first issue. The second issue is addressed in a report prepared by the authors for the USDA which was forwarded to Congress (Butler and Marion, 1983).

[1] The study from which this paper was condensed was conducted for the Agric. Marketing Serv. by the Food System Research Group, Univ. of Wisconsin-Madison. Financial support was provided by the Agric. Marketing Serv. and Economics Res. Serv. of the USDA and by the Univ. of Wisconsin. The views expressed do not necessarily reflect those of any of the funding organizations.

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Under PVPA, the Plant Variety Protection Office of USDA may issue a certificate of protection to the breeder of a new cultivar reproduced from seed. (First-generation hybrids, fungi, and bacteria are excluded from proteciton.) The certificate gives the breeder 1) the exclusive right to sell or advertise, and to license other persons to sell seed of the registered new cultivar and/or the reproductive material of these plants and 2) the right to levy and collect royalties from persons selling or using the new cultivars registered under the Act.

Participation in plant variety protection (PVP) is voluntary for the breeder; enforcement is the sole responsibility of the breeder through civil law. (The government does have responsibility for enforcement of Title V of the Federal Seed Act, which allows the developer of a new cultivar to specify that seeds be sold by cultivar name only as a class of certified seed.) The breeder must submit at the time of application and replenish periodically 2500 viable seeds of the new cultivar, which are preserved in the National Seed Storage Laboratory. Legal protection is extended to a cultivar for 18 years (amended from 17 years in 1980). Farmers may reproduce protected seed for their own use, provided they do not sell, offer for sale, or advertise the seed on a commercial basis (PVPA includes a clause known as "crop exemption," which allows a farmer not normally engaged in the commercial sale of seed to sell seed of a protected cultivar to another farmer or farmers.).

STUDY METHODOLOGY

The information in this study came from a number of sources, but depended to a large extent on surveys of seed companies and state agricultural experiment stations carried out by the authors. The seed industry survey consisted of two separate questionnaires: a financial data questionnaire and an attitudes and opinions questionnaire. Of the 153 companies with known plant breeding programs, 60 completed the financial data questionnaire. One hundred of these companies plus 42 companies without breeding programs completed the attitude and opinion survey. We estimate that the 60 sample firms that provided financial data represent about 35% of all companies with plant breeding programs; account for about 47% of the total research and development (R&D) expenditures by companies with plant breeding programs; and hold about 51% of all PVP certificates issued.

The survey of state agricultural experiment stations involved the director and up to 10 plant breeders at each

of 51 agricultural experiment stations (AES). Responses were received from 269 public plant breeders and 44 AES directors at 50 AES's. The detailed results of these surveys are reported in Butler and Marion (1983), from which this paper is condensed.

In trying to assess the impacts of a law, one is faced with the counterfactual proposition, "What would have been without the law?". In most cases, this is impossible to answer precisely; therefore, the impact of the law is difficult to isolate from the impact of other factors. In this study, economic theory and common sense suggested several expected effects of PVPA or hypotheses to be tested. Our hypothesis tests are relatively "soft," however, relying for the most part on several pieces of evidence that may include the effects of other forces besides PVPA. In the case of soybeans [*Glycine max* (L.) Merr.], we believe the circumstantial evidence is sufficiently strong to conclude that PVPA accelerated plant breeding activity. On other crops, the evidence is more equivocal.

INCENTIVES FOR RESEARCH AND DEVELOPMENT (R&D)

The profit opportunities represented by PVPA vary considerably by species. Private companies would be expected to focus their R&D expenditures on those crops where the expected returns are the greatest. Potential profits are affected by:

1. Total quantity of seed sold by the seed industry which is determined by a) acres planted to a crop, and expected future growth or decline in acreage, b) the seeding rate, and c) the proportion of seed that is purchased from the industry.
2. Potential for genetic improvement, including hybrid potential.
3. The pricing discretion of companies developing new cultivars. This is likely to be influenced by the level of competition, the importance and availability of public cultivars and the ability of farmers to save seed.
4. Difficulty and expense of developing new cultivars.

While it is not possible (or desirable) to examine all seed species, the wide diversity of seed markets is illustrated by the characteristics of nine different seed species: corn (*Zea mays* L.), soybeans [*Glycine max* (L.) Merr.], wheat (*Triticum aestivum* L.), cotton (*Gossypium hirsutum* L.), alfalfa (*Medicago sativa* L.), barley (*Hordeum vulgare* L.), rice (*Oryza sativa* L.), peas (*Pisum sativum* L.), and beans (*Phaseolus vulgaris* L.) (because of data limitations, peas and beans are grouped in Table 1). It is estimated by the authors that these nine species account for roughly 90% of total plant breeding research and development (R&D) by the commercial seed industry. These seed species also represent about 75% of the total value of seeds sold by the industry and 70% of the total PVP certificates (Butler and Marion, 1983).

Seed purchased from the industry as a percent of seed used shows a range from 35% for wheat to 95% for corn and alfalfa. These figures reflect, to a certain extent, the ability of farmers to keep seed from one crop year to the next. Whereas this is easily done by farmers commercially producing soybeans, wheat, cotton, and barley, alfalfa is normally harvested for forage, not seed. Peas and beans, normally harvested for vegetable purposes, are not sufficiently mature to use as seed. In the case of hybrids such as corn (which are excluded from protection under the PVPA), farmer-saved seed may produce plants with different characteristics from the F_1 hybrid. The R&D expenditures on corn have been high, reflecting the high pay-off of successful hybrids.

PRIVATE SECTOR INVESTMENTS IN PLANT BREEDING RESEARCH AND DEVELOPMENT

The patterns and trends of private sector investments in plant breeding research and development can be examined in two major ways. Expenditures on R&D reflect the input to innovative activity, while new cultivar releases (including those protected) reflect the output of

Table 1. Summary statistics of U.S. seed industry: Selected species.††

	Total market value 1979 ($000's)	Seed purchased from seed industry as percent of seed used	Value of stock supplied by seed industry, 1979 ($000's)	Percent value added by seed industry§ 1979	Percent of total value added by seed industry—all species, 1979
		%			
Corn	996 587	95	946 758	95	47.0
Soybeans	816 084	60	489 650	48	12.3
Wheat	664 680	35	232 638	50	6.2
Cotton	120 450	50	60 225	83	2.6
Peas and beans	52 635	85	44 740	85	2.0
Alfalfa	190 166	95	180 658	46	4.3
Barley	69 876	50	34 938	54	1.0
Rice	100 500	70	70 350	60	2.2

	Percent acreage planted to protected cultivars, 1979–1980		Percent acreage in public cultivars 1979–1980	Percent of PVP certificates 1981¶	Percent of 153 presurvey firms with breeding programs#
	Private	Total			
Corn	0	0	0	0	35.3
Soybeans	6.6	30.0	70	22.4	26.8
Wheat	1.1	11.0	59	10.8	22.2
Cotton	37.0	46.0	19	10.4	14.4
Peas and beans	--	--	--	19.6	18.3
Alfalfa	††	††	--	1.9	18.1
Barley	3.0	3.0	76	1.5	9.2
Rice	0.4	0.4	94	1.1	3.3

† Columns 1 to 5 are updated from Harvard Business School Case Study 4-375-109 of Pioneer Hibred, Inc., 1978. Data for 1979 were obtained from various sources including Am. Seed Trade Assoc. and USDA. Columns 6, 7, and 8 were derived from various publications of the Crop Reporting Service, USDA.

‡ Source: Butler and Marion, 1983.

§ Percent value added is estimated as $P_S - P_C/P_S$; where P_S = price of seed, P_C = price as commodity.

¶ Plant Variety Protection Office, Beltsville, MD.

From survey of U.S. seed industry conducted by Butler and Marion (1983).

†† Negligible.

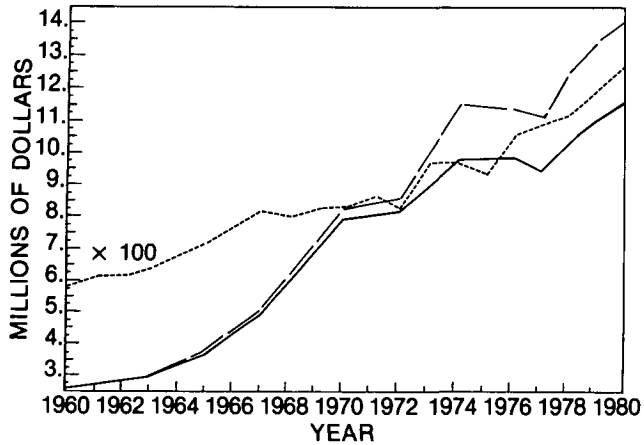

Fig. 1. Private firm R&D expenditures (deflated) and output index for seeds, 1960–1980 (Butler and Marion, 1983; based upon survey of U.S. seed industry, and USDA Agricultural Statistics, 1972 and 1981.) Total R&D expenditures of: ——— Base 14 firms—plant breeding programs established prior to 1960. ——— 44 firms—including plant breeding programs established after 1960. ---- Index of output of seed (total seed expenditures by farmers adjusted for Prices paid by farmers index 1967 = 100).

innovative efforts. Because of the substantial time period required to develop new cultivars (a minimum of 6 years and sometimes up to 20 years), we would expect changes in R&D inputs to occur several years before changes in output. Changes in R&D input may have taken place in anticipation of the passage of PVPA.[3]

Research and development inputs to plant breeding activity were measured in three ways: 1) the number of firms with plant breeding programs, 2) firm R&D expenditures, and 3) the number of plant breeders employed by the private sector. In all three cases, the evidence presented a somewhat mixed picture of the effects of PVPA on R&D activity. Of the 60 companies providing information on their plant breeding programs, almost one half of them started their plant breeding programs after 1970. From the available information, these companies were largely additions, not replacements, to the ranks of private plant breeders. Total R&D expenditures (deflated)[4] of surveyed seed companies increased faster than the growth in quantity of seeds sold from 1960 to 1970. This increase, particularly during the late 1960's, may have stemmed in part, from anticipation of PVPA. From 1970 to 1980, the R&D expenditures of older firms grew at about the same rate as the quantity of seed sold. Total R&D expenditures by all sample companies grew at a faster rate because of the increased number of firms with plant breeding programs (Fig. 1).

Research and development expenditures were generally 1.5 to 4% of seed company sales (Table 2). Firms

[3] The meetings on breeders rights in the mid 1960s and the efforts by American Seed Trade Association in the late 1960s to have legislation introduced may have led some companies to increase their R&D efforts prior to 1970. Perrin et al. (1983) note that some seed firms in their survey initiated breeding programs in anticipation of PVPA.

[4] R&D expenditures deflated by consumer price index (CPI) 1967 = 100.

Table 2. Average R&D expenditures as a percent of sales for four groups of seed companies, 1960–1980.†

	Number of firms and year began plant breeding program			
	1960 (14)	1967 (7)	1970 (16)	1976 (14)
1960	6.9 (3.2)‡	--	--	--
1963	6.5 (3.4)	--	--	--
1965	6.9 (3.8)	--	--	--
1967	6.8 (4.4)	2.7 (1.4)	--	--
1970	7.6 (6.1)	2.2 (1.8)	2.1 (2.5)	--
1972	8.7 (5.6)	2.2 (1.7)	2.1 (2.7)	--
1974	8.2 (4.3)	2.0 (1.6)	2.2 (2.3)	--
1976	7.3 (3.7)	1.9 (1.6)	1.9 (2.9)	4.1 (3.7)
1977	7.8 (3.3)	1.7 (1.5)	1.9 (2.8)	4.3 (3.4)
1978	7.9 (3.7)	2.1 (1.6)	2.0 (2.9)	4.6 (3.7)
1979	9.0 (4.0)	2.0 (1.7)	2.0 (2.9)	4.6 (4.2)
1980	8.8 (4.1)	2.2 (1.8)	1.9 (3.1)	4.8 (4.3)

† Source: Butler and Marion, 1983; based upon survey of U.S. seed industry.
‡ Average R&D to sales ratios in parentheses are weighted by company sales. Figures not in parentheses are simple averages of company R&D to sales ratios.

with older plant breeding programs generally had higher R&D to sales ratios than companies with newer programs. The 14 companies with plant breeding programs that were initiated prior to 1960 substantially increased R&D intensity from 1967 to 1970, possibly in anticipation of PVPA. However, the growth in R&D to sales in these companies declined rather sharply from 1972 to 1976.

The average number of plant breeders employed increased from about two per firm in 1960 to 3 per firm in 1970, and to about 5 per firm in 1980. Deflated R&D expenditures per plant breeder increased during the period 1960 to 1970 (from about $30 000 to $40 000 per plant breeder in 1967 dollars) and decreased again (to about $30 000 per plant breeder in 1967 dollars) from 1970 to 1980. The largest increase in the number of plant breeders hired by the private sector was in the period 1970–1975.

Based upon the above evidence, there is a reasonable probability that the PVPA has had some influence on plant breeding R&D activity in the private sector. The sharp increases in R&D expenditures during the period 1967–1970 by firms with established plant breeding programs may have been in anticipation of the PVPA. The relatively large number of companies that initiated plant breeding programs in the late 1960s and 1970s may also have been responding, in part, to the incentives of PVPA. The increase in the number of plant breeders hired by the private sector in the period 1970–1975 was probably influenced by the passage of the PVPA. However, the change in R&D activity was not dramatic; during the 1970s, increases in R&D expenditures approximately kept pace with the increases in sales by the companies studied. The change in R&D activity also may have been influenced by other factors such as speculation about world food shortages and the green revolution. Data on R&D activity by species reveals a somewhat clearer picture.

Data provided by survey respondents on research expenditures and new cultivar releases by species were contrasted to see if a shift occurred in the distribution of R&D expenditures (Table 3) and the number of new cultivars released (Table 4). The proportion of total

Table 3. Distribution of R&D expenditures across five seed species, 1970–1980, 14 seed companies.†

	($000s) Total R&D expenditures	Percent of total R&D expenditures for each group				
		Corn	Alfalfa	Wheat	Soybeans	Cotton
1970	3 417	79	9	7	1	4
1972	3 943	77	8	9	2	5
1974	5 593	75	7	8	6	4
1976	8 390	73	6	11	7	3
1977	8 562	68	7	11	10	4
1978	10 261	71	6	9	10	4
1979	11 042	70	6	8	11	4
1980	12 131	71	7	9	11	3

† Source: Butler and Marion, 1983; based upon survey of U.S. seed industry.

Table 4. Number of new cultivars released, by species, by year 1970–1980.†

	Corn (12)‡	Alfalfa (6)	Wheat (12)	Soybeans (11)	Cotton (8)
1970	57	6	2	1	7
1972	40	3	4	3	3
1974	43	5	3	4	6
1976	52	4	7	6	9
1977	35	1	6	10	2
1978	24	7	7	15	4
1979	24	4	6	11	5
1980	35	2	11	25	6

† Source: Butler and Marion, 1983; based upon survey of U.S. seed industry.
‡ Number of firms in parentheses.

R&D expenditures devoted to soybeans, and to a lesser extent wheat, increased during the 1970s. The number of new cultivars released of these two species also increased rather sharply during the decade. While alfalfa and cotton showed no detectable trends, a decrease in the percentage of total R&D expenditures devoted to corn appears to have resulted in a decline in the number of new corn cultivars released.

Soybeans and wheat, for which more PVP certificates have been issued than other seed species, also experienced an upward trend in the number of successful PVP applications during the period 1971 to 1982 (Table 5). With the possible exception of peas, other crops exhibited no significant trend. Most PVPA certificates are held by larger seed companies with older plant breeding programs (Butler and Marion, 1983). As of 1 Jan. 1984, 57% of all certificates were held by 27 organizations, 23 of which were private companies. Twenty-one of these companies started their plant breeding programs before 1960.

In summary then:

1. Research and development investments by seed companies increased most rapidly during 1967 to 1970, possibly in anticipation of the passage of PVPA. During the 1970s, company R&D expenditures increased at about the same rate as company seed sales.

2. A large number of companies initiated plant breeding programs during the late 1960s and 1970s, thereby adding to the total private expenditures on plant breeding.

3. Research and development expenditures shifted away from corn and toward soybeans during the 1970s.

4. The number of soybean and wheat cultivars released by sample firms during the 1970s increased rather

Table 5. PVP certificates issued by fiscal year of application, 1971–1982.†

	Soybeans	Wheat	Alfalfa	Cotton	Peas	Garden beans‡
1971	9	1	--	6	4	14
1972	8	11	2	21	5	6
1973	13	5	2	7	6	8
1974	15	11	1	5	8	10
1975	11	7	2	7	16	8
1976	13	16	3	6	7	9
1977	20	15	--	10	16	16
1978	20	11	2	10	10	3
1979	35	8	2	8	8	3
1980	38	13	5	8	18	13
1981	51	15	2	11	12	14
1982	42	14	4	14	13	14
Total	275	127	25	113	123	111‡

† Prepared from Plant Variety Protection Office Journal. Figures are as of 1 Jan. 1984.
‡ Excludes field and lima beans.

sharply. The number of PVP applications and certificates for these two crops also showed a strong upward trend—especially from 1975 on. Soybeans and wheat account for one-third of the certificates issued from 1972 through 1982.

Although the causal role of PVPA is impossible to document, these data suggest that PVPA has had a positive effect on private plant breeding R&D for soybeans and to a lesser extent for wheat. Except for some decline in the percent of R&D funds devoted to corn, other crops appear to have been affected little by PVPA.

PUBLIC SECTOR INVESTMENTS IN PLANT BREEDING R&D

A survey of State Agricultural Experiment Stations (AES) by Hanway (1978a, b) indicated that a modest reduction in new cultivar releases from AES had occurred since 1970. Hanway ascertained that while private companies dominate the breeding and release of seeds for six crops [corn (*Zea mays* L.), sorghum (*Sorghum vulgare* L.), sugar beets (*Beta vulgaris* L.), cotton (*Gossypium hirsutum* L.), alfalfa (*Medicago sativa* L.) and tobacco (*Nicotiana tabacum* L.)], AES represent the major source of new cultivars in nearly all other cases (horticultural and vegetable crops were omitted from the survey). In addition, Hanway found that AES expected to continue to release new cultivars and that the enactment of PVPA had not significantly reduced plant breeding at AES.

Current Research Information Service (CRIS) data indicate that funds allocated for plant breeding and genetics research since 1970 have been a relatively constant percentage of total research funds available to AES. Although USDA funds since 1970 have represented a declining proportion of plant breeding and genetic research support, this has been offset by increases in state appropriations. In 1970 USDA funds represented about 40 percent of the total public expenditures on plant breeding and genetics research. In 1979 this had decreased to 33 percent (Table 6).

The survey of AES Directors and public plant breeders sought information on the impact of the PVPA on

Table 6. Plant breeding and genetic research expenditures at public plant breeding institutions 1970-1979.†

	Expenditures for plant breeding and genetic research		Source of research funds (Percent of total)		
				Funds	
	$M	Percent of AES research $	USDA	Federal	Non-Fed.
1970	32.2	11.6	39.8	15.5	44.4
1971	34.1	11.4	39.3	15.5	45.2
1972	36.3	10.2	32.7	14.9	47.4
1973	40.3	10.5	37.5	14.4	48.1
1974	43.9	10.4	35.5	14.1	50.3
1975	49.1	10.2	35.4	14.1	50.5
1976	52.6	11.1	34.5	14.2	51.2
1977	63.7	10.7	34.7	14.8	50.5
1978	70.9	10.9	33.7	17.1	49.2
1979	79.8	10.5	33.0	17.1	49.4

† Source: Current Research Information Service (CRIS), USDA.

AES research. The majority of public plant breeders were of the opinion that PVPA has had no significant effect on the amount or direction of applied plant breeding research at their AES. Some mentioned that they had noticed a shift in emphasis from public to private research, and that universities appeared to be moving toward more basic research.[5]

There appears to be a growing debate concerning the direction of public plant breeding research. The American Seed Trade Association (ASTA) and some of its members have advocated that public institutions reduce their research on cultivar development and increase basic research. For example, two points in an October 1981 draft position statement by ASTA stated:

> The primary role of the public breeder should be that of 'basic research,' the development and general release of improved germplasm and the training of future plant breeders. However, it is proper for public breeders to breed and release finished varieties of plant species in which industry breeders are not adequately serving the public needs.
>
> Release of publicly bred varieties on a royalty basis may place public institutions in direct competition with private breeders. The diversity of ASTA membership precludes development of a consensus on this issue.

Many public plant breeders disagree with these positions. The public plant breeders in two regional research committees found ASTAs policy statement "not in the best interest of the consuming public and our nation's agriculture" (minutes of NCS-1 and NCS-2 Meeting, 5-6 Apr. 1982).

Interviews with Agricultural Experiment Station administrators indicated that the current pressure from the private sector is reminiscent of the pressure during the 1950s and 1960s for AES to discontinue research on the hybrid corn cultivars. The outcome of the current debate will have an important effect on future competition in the seed industry and the economic consequences of PVPA.

The above findings indicate that the PVPA has had a modest impact to date on public plant breeding research. There may have been a slight shift in AES plant breeding and genetic research monies toward basic research; however, the evidence on this is not very compelling. Many AES have protected a few new cultivars.[6] Relative to the private sector, however, public sector participation in PVPA has been slight. Some public plant breeders feel that protection of publicly developed cultivars is in conflict with the mission of a publicly funded research institution (Peterson, 1981). The majority of protected public cultivars are broadly released, however, so that large numbers of companies have access to them.

CONCLUDING COMMENT

In an industry in which new cultivars often require 10 years or more to develop, the effects of the PVPA are difficult to detect after only 12 years. Protected cultivars hold a small share of the market in most seeds. For example, there have been more certificates issued to soybeans than any other species (22% of total). Yet in 1980, less than 10% of the soybean acreage was planted to privately protected cultivars. Thus it may require another 10 to 20 years before the effects of the PVPA are more clearly visible.

However, evidence to date indicates that PVPA has had little effect on public sector research, and a rather selective effect on private sector research. While PVPA appears to have stimulated plant breeding activity on soybeans, and to a lesser degree wheat, there is little evidence that it has affected the plant breeding of other crop species.

[5] Some respondents added that there appeared to be less funding for graduate students, and a few complained of pressures to discontinue release of cultivars even in crops where the private sector was not engaged in breeding research. Public plant breeders were also asked to assess the impact of the PVPA on expenditures for public plant breeding research on open-pollinated, pureline cultivars and on hybrids. The responses indicated a perception that PVPA has had, if anything, a slight negative effect on public plant breeding research expenditures.

[6] Of the total certificates issued to 31 Dec. 1982, 14% had been granted to public plant breeding institutions.

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