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PATENTING LIFE FORMS: ISSUES SURROUNDING THE PLANT VARIETY PROTECTION ACT

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INTRODUCTION

This paper examines the issues surrounding the patenting of life forms, specifically the social and private costs and benefits of the Plant Variety Protection Act (PVPA) (Plant Variety Protection Act, 1970). The PVPA is a current issue, encompassing all the elements of the economic, social, and moral controversy aroused by the broader issue of patenting life forms generally.

The subsequent sections of the paper outline the specific issues surrounding the PVPA, discuss the issue of plant patenting, present the arguments favoring and opposing plant patenting, and, finally, present an analysis of the major issues of the PVPA.

A patent, simply stated, is the awarding of exclusive ownership of a new invention, enabling the developer to obtain whatever rewards that might accrue from the invention. A government-granted patent confers certain rights and privileges on its owner and is considered private property. Patents are thus a means of providing incentive to engage in creative activity.

Patent protection and a competitive market structure have coexisted as basic tenets of society in the United States for nearly 200 years. Yet, the inherent characteristics of patent protection seem in conflict with conditions necessary for the efficient functioning of a competitive market structure. Patents may be barriers to market entry. The number of buyers and sellers may be determined by the patent holder through licensing or contractual arrangements. Patents may impede the flow of information and the mobility of factors of production. By definition, the invention is distinct and unique; this implies the absence of existing comparable products, eroding the assumption of homogenous goods. Further, the patent holder has been granted exclusive power to negotiate contractual arrangements regarding the use of the product, thus enabling an influence over price.

There are two reasons why a competitive mar-

ket structure can be maintained concurrent with a patent system. The first is public perception. The patent is not viewed as government regulation with a purpose, but as a fundamental part of the institution of private property; not as the creation of a statutory monopoly, but as protection against theft. The second reason lies in the economic justification for government intervention: whenever the private marginal value product is less than the social marginal value product of an activity, and the private marginal cost exceeds the social marginal cost, it behooves the government to direct resources toward that activity, since societal welfare can be improved.

The competitive market thus tolerates government intervention when an activity is characterized by the described marginal benefit-cost relationship. More to the point, the government intervention encourages such activities. Patent protection, then, is a means to achieve this end—by temporarily raising the private marginal value product to induce the private sector to undertake the desired activity. The PVPA serves to illustrate the costs and benefits of government intervention in the form of patent protection.

The PVPA (P.L. 91-577) was enacted into law on December 24, 1970. Its enactment was motivated by a desire to increase the return on private research investment through enabling patents to be obtained for sexually reproduced plant varieties.¹ Amendments to the original act were proposed in 1979 to extend the life of the patents and to broaden the list of plants eligible for patenting. When the amendments, bills H.R. 999 and S. 23, were first considered by the House and Senate Agriculture Committees, the opposition became so intense that the hearings were postponed ("Opposition to Seed Law Mounts," 1979). It was nearly one year later, June 4, 1980, before the House Agriculture Committee passed the amendments in a roll call vote of 35 to 2. The amendments were passed by the Congress in December, 1980, before the 96th Congress adjourned.

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¹The stated intent of PVPA is to encourage the development of novel varieties of sexually reproduced plants, to make them available to the public, to provide protection to those who breed, develop, or discover them, and thereby promote progress in agriculture in the public interest.

THE PATENT ISSUE

The basic issue underlying the PVPA is whether patents on life forms, specifically those awarded to developers of new plant varieties, result in a loss of genetic diversity and increase the tendency for significant economic concentration among a few firms in the seed industry (U.S. Congress, House Committee on Agriculture, 1979, 1980). Briefly, genetic diversity is determined by the extent to which production of a specific crop is dependent upon one of a very few varieties of seeds. The economic concentration issue arises from concerns that patents impeded the information flow in the marketplace, create barriers to entry, and enable undue price enhancement. Patents are a recognized statutory monopoly, and although it does not necessarily follow that statutory monopolies must also be market monopolies, it is nevertheless a continuing concern. The issue also assumes an even broader context: the desirability of granting patents on life forms of any kind.

Three recent events have converged to make this a topical social issue. The first is the proposed amendments to the 1970 PVPA (Plant Variety Protection Act, 1980). (P.L. 96-574 made several changes most of which are not substantive, intended only to clarify the Act.) The two most significant amendments would: (1) delete from the Act section 144, which states, "The provisions of this Act shall not apply to the seeds, plants, or transplants of okra, celery, peppers, tomatoes, carrots, and cucumbers." This would broaden the list of eligible plants from 222 to 228; (2) extend the life of patents from 17 to 18 years; the extension would harmonize coverage with European laws, thus enabling the United States to enter the International Union for the Protection of New Plant Varieties (UPOV).²

The second event is litigation decided by the Supreme Court in June, 1980. That case stems from patents issued by the Court of Customs and Patent Appeals on March 28, 1979, to the General Electric Corporation and Upjohn Pharmaceuticals for genetically engineered life forms (the manipulation of genes, which transmit heredity in cells, to create new organisms) ("The Case Against Patenting Life," 1979). The Patent and Trademark Office had refused to grant patents arguing that Congress never intended that forms of life be patentable under the existing Patent Law (35 U.S.C. 101). However, the Court of Customs and Patent Appeals held that "there was no justification for excluding an 'invention'

merely because it is 'alive' . . . from the standpoint of construing the patent statutes we do not see . . . any sound reason for making the distinction . . . here between the living and the dead" ("The Case Against Patenting Life," 1979, p. 4).

The Supreme Court, considering an appeal, upheld the decision of the lower court by a vote of 5 to 4 to grant the patent for a microorganism created for use in cleaning accidental oil spills. Considered a key case in the Court's Spring decisions, Chief Justice Warren Burger stated that, "it was not the Court's business to thrash out the broader questions raised by critics of genetic engineering . . . the opponents present a gruesome parade of horrors. . . . We are without competence to entertain these arguments—either to brush them aside as fantasies generated by fear of the unknown or to act on them. The choice . . . is a matter of high policy for resolution within the legislative process after the kind of investigation, examination, and study that legislative bodies can provide and courts cannot" (Burger, 1980, p. 158).

The third event relates to the current examination of the structure of agriculture and the possible ramifications of the PVPA. The concern for economic concentration and other adverse societal effects was stated by Cary Fowler of the National Sharecroppers Fund in a letter to Secretary of Agriculture Bob Bergland: "The type of seed grown and their characteristics is one of the most crucial factors affecting the structure of agriculture. Some varieties lend themselves to large, mechanized farming systems. Others literally, can be grown only by small farmers" (Fowler, 1980, p. 1). Fowler also pointed out that types of seeds determine differences in production inputs required (such as amounts of water, pesticides, and fertilizers) and in the nutritional characteristics of the product obtained.

LEGISLATIVE HISTORY

The Plant Patent Act (Plant Patent Act, 1930) provides for the patenting of certain types of *asexually* reproduced plants, with the intent to foster plant breeding and the development of new types of crops with desirable characteristics. It did not cover plants that were *sexually* reproduced. Seeking to extend the coverage, the American Seed Trade Association (ASTA) in 1961 appointed a Breeders' Rights Study Committee to investigate the ways and means of accomplishing this (U.S. Congress, House Com-

²UPOV, the International Union for the Protection of New Plant Varieties, is an intergovernmental organization whose headquarters is in Geneva, Switzerland. It is affiliated by an agreement of cooperation with the World Intellectual Property Organization, a specialized agency of the United Nations system concerned with protecting patents, trademarks, copyrights, and other kinds of intellectual property. UPOV provides protection of new varieties of plants by granting plant breeders' rights, either in the form of a patent or a special title of protection, or by both. It began in 1961, and now has 12 member nations. Considerable concern has arisen that membership in UPOV will make patent enforcement a serious issue. This concern emerges from the European Economic Community (EEC) Common Catalogue, a legislative attempt to standardize vegetable products marketed in the EEC. It is termed a preventive measure, to help keep patent infringement to a minimum, since cultivation of excluded varieties is punishable by fines. While the Common Catalogue is not sanctioned by UPOV, there is still some question whether membership in UPOV will lead to a catalogue in the United States. Furthermore, since the EEC adopted the Common Catalogue, hundreds of seed varieties have been declared illegal; this, they are no longer offered for sale and are disappearing. Several studies by genetic research centers speculate that by 1991, nearly three-quarters of all European vegetable varieties will be extinct.

mittee on Agriculture, 1970). Subsequently, legislation to amend the 1930 Act was proposed—to insert the words “or sexually” in sections 161 and 163 after the words “asexually”—with the effect of enlarging the class of patentable plants (U.S. Congress, House Committee on Agriculture, 1970). The Department of Agriculture under Secretary Orville Freeman opposed the amendment on the grounds that “it would threaten the continued existence of its long standing programs for developing and introducing new varieties of seeds and it is scientifically and legally unsound.” (U.S. Senate, Senate Committee on the Judiciary, 1968, p. 715). After consideration, the Senate Judiciary Subcommittee on Patents, Trademarks, and Copyrights voted not to report the bill.

A major reason for failure of the amendment appears to have been disagreement over the feasibility of achieving plant protection for sexually reproduced plants through the 1930 plant patent statute. In fact, patenting for sexually reproduced plants was viewed by many to be separate from other patents because it involved a life form, and that such unusual inventions should thus be treated by new laws (U.S. Congress, House Committee on Agriculture, 1970).

The ASTA managed to get the issue resurfaced in 1969 with new legislation, which eventually became the Plant Variety Protection Act of 1970 (Plant Variety Protection Act, 1970). The eventual Act was the product of substantial compromise in language and intent. The purpose of the Act is “to issue ‘certificates of plant variety protection’ assuring developers of novel varieties of sexually reproduced plants of exclusive rights to sell, reproduce, import or export such varieties or use them in the production of hybrids for a period of 17 years” (Plant Variety Protection Act, 1970, p. 1). The effect was establishment of a patenting system for sexually reproduced plants. However, due to the opposition by major vegetable processors, six vegetables, okra, carrots, cucumbers, tomatoes, celery, and peppers, were excluded (U.S. Congress, House Committee on Agriculture, 1970).

The Plant Variety Protection Office in the Agricultural Marketing Service (AMS) of USDA, established under the authority of the 1970 Act, (Plant Variety Protection Act, 1970) proposed in 1979 the most recent amendments to the PVPA. Consideration of the amendments provided a forum for renewed opposition to the Act itself, allowing the economic, moral, and social propriety of the original Act to again be questioned.

PATENTING LIFE FORMS: THE ARGUMENTS

The nexus of the issue over the proposed amendments to the 1970 Act is that proponents

think it should be strengthened via amendments, while opponents question even whether it is desirable to grant patents in this area, and, as such, their position contains the broad spectrum of arguments.

The concept of patenting a variety of a good that is implicitly considered to be publicly owned touches a “raw nerve” in many people; it evokes an emotion that transcends social and professional strata. In particular, the fear is that patenting plants is a dangerous precedent to patenting more sophisticated life forms, as in the case of General Electric’s microorganism. As a corollary, the argument is often extended to any type of patenting since (except for literary contributions) all inventions are, at the extreme, merely improvements on existing natural materials. In fact, this was the basis for Chief Justice Burger’s position in favor of General Electric (Burger, 1980).

Proponents of the PVPA and the proposed amendments include government and industry, with arguments based largely on the need for economic incentives to induce private research and development.³ They contend that plant protection will: (1) greatly stimulate private plant breeding research; (2) allow agricultural experiment stations to increase needed basic research; (3) permit public expenditures for applied plant breeding to be diverted to important areas that industry might not pursue; (4) give farmers and gardeners more varietal choice, and higher yielding, better quality varieties; (5) make American agricultural products more competitive in world markets; (6) provide benefits to consumers of crops and crop-products, either through improved quality or greater production; and, (7) foster continued breeding of new varieties by university experiment stations, which can license them to seed companies for a share of the proceeds. Vegetable processors who objected to the PVPA in 1970 now support the Act and the amendments. Their initial objections were that patent protection would cause prices of these vegetables to increase tremendously. They apparently do not feel that this has occurred, and thus decided to support the inclusion of the six vegetables.

Additionally, United States membership in UPOV is considered beneficial by proponents of plant protection. Proponents assert that UPOV membership will assure extended protection benefits. While membership in UPOV does not give patent holders protection in member nations, members may apply for patent protection under common by-laws adopted by the member nations. Furthermore, member nations are required to establish a system of rights for plant breeders. In the United States, plant rights are administered by the Patent and Trademark Office

³ USDA, the American Seed Trade Association, private seed companies, the North Carolina Crop Improvement Association, the American Patent Law Association, the Nurserymen’s Association, and the U.S. Departments of State and Commerce.

and the USDA's Plant Variety Protection Office. The intent is to streamline international bureaucratic procedures by a homogeneous set of provisions designed to protect breeder's rights and facilitate the transfer of technology of new varieties without regard for geographical, legal, or political boundaries.

Parties opposed to plant protection include groups representing various environmental, research, technological, and consumer interests, the Foreign Agricultural Organization (FAO), and various social and genetic scientists in universities across the country.⁴

Arguments opposing plant protection range from broad philosophical and moral arguments, to allegations concerning detrimental economic impacts, such as concentration, loss of information exchange, and higher seed prices (U.S. Congress, House Committee on Agriculture, 1979, 1980). Underlying this opposition is concern for the preservation of genetic variability. The opposition to plant protection varies in intensity. There are those (such as the National Sharecroppers Fund) who adamantly contend that the PVPA directly results in an irrevocable loss of genetic diversity, leads to a legalization of monopoly in the seed industry, and is a dangerous precedent for extending patents to other life forms. At the other end of the spectrum are those who feel that plant protection is a contributing factor to the situations noted above, but by no means, the sole cause. This group proposes that the burden of proof, insofar as plant patent legislation has negative social or economic implications, be borne by advocates of plant protection legislation, while the former would prefer repeal of all such legislation.

Thus, it would seem that, underlying all the various arguments surrounding the PVPA and proposed amendments, there are really two central underlying issues—the economic concentration of the industry and the loss of genetic variability. These are further examined below.

ECONOMIC CONCENTRATION IN THE SEED INDUSTRY

Since 1970, a number of independent seed firms have been purchased by large (some multinational) corporations, many of whom are involved in the agrichemical and/or petrochemical business. Some of the recent acquisitions are shown in Table 1. As evidence supporting allegations of economic concentration, however, this is liable to be charged as being only circumstantial, since the intent of acquisition is not explicit, and the dates of acquisition are coincidental with the passage of the PVPA. Nevertheless, consider the

TABLE 1. Some Recent Seed Company Acquisitions

New Owner	Seed Company	Date Acquired ^a
Celanese	Cepril Inc.	1973
	Moran Seeds	1974
	Joseph Harris	1976
Central Soya	O's Cold Seed	1976
Ciba-Geigy	Funk Seeds International	1976
	Stewart Seeds	NA
	Louisiana Seed	1979
Garden Products	Garney Seeds	1970
International Multifoods	Baird Inc	NA
	Lynk Brothers	1972
I.T.T. ^b	Burpee Seeds	1978
Kleinwanzieberger Swatzucht AG	Coker's Pedigreed Seed Co.	1977
NABP (Olin & Royal Dutch Shell)	Agripro Inc.	1973
	Tekseed-Hybrid	1974
Occidental Petroleum	Ring-Around Products	1975
Pioneer Hi-Bred	Lankhart	NA
	Lockeet	NA
	Arnold Thomas Seed Co.	1975
Pfizer	Clemens Seed Farms	1975
	Jordan Wholesale Co.	1975
	Trojan Seed	1975
	Warwick Seeds	1975
Purex	Hulting Hybrids	1977
Rorer-Amchem	Jacques Seed	1970
Sandoz	National M-K	1975
	Northrup-King	1975
	Rogers Bros.	1975
Southwide	Delta & Pine Land	NA
	Greenfield Seed	1978
Tate & Lyle	Berger & Plate	NA
Tejon Ranch Co.	Waterman-Loomis Inc.	1977
Union Carbide	Keystone Seed	1977
Upjohn Pharmaceutical	Associated Seeds	1972
	Asgrow Seeds	1972

Source: Fowler, Cary. *Graham Center Seed Directory*, North Carolina, 1979.

^a Date acquired is approximate; obtained in conversation with ASTA, April 22, 1980.

^b I.T.T. also owns O. M. Scott & Sons, acquired in 1964.

following scenario as a possible justification for opponents' concern for growing concentration in the seed industry: the opportunity for vertical and horizontal integration, as well as diversification, presents itself in this situation. Seeds, fertilizer, and pesticides are all marketed similarly and simultaneously. Acquisition of seed companies by firms selling the other inputs can reduce costs while expanding markets for these firms. In some instances, fertilizers and pesticides are complements for seeds. For example, seeds producing a high yield per acre but with inadequate resistance to disease will require more pesticide. Another reason for acquisition of seed companies lies in the potential for seed coating and pelleting. The seed thus becomes a delivery system for chemicals and biologicals to the field. Additionally, research may be coordinated among these inputs in a more effective and efficient manner. Finally, membership in UPOV would extend breeders' rights to member nations. If a firm acquiring a seed company is mul-

⁴The National Sharecroppers Fund, the Consumers Federation of America, the National Center of Appropriate Technology, the Environmental Defense Fund, the Environmental Policy Center, and the People's Business Commission. In addition, the National Farmers Union and the National Association for Gardening urged further study of the act prior to passage of the amendments.

tinational, membership in UPOV could potentially "homogenize" its markets, enabling the establishment of a system that transcends geographic boundaries. This scenario would suggest that the seed industry could be a catalyst for expanding seed and agricultural chemicals markets in developing countries, as well as domestically.

However, there may be other reasons for acquisition of seed companies. One is the declining value of the dollar, enticing foreign based corporations to "buy American." Another stems from the consequences of the U.S. tax laws. "A study of the widely published list of seed companies which have been acquired shows that 20 out of 27 companies listed were owned and operated by individual proprietors or a closely held partnership. In these cases, the tax structure of aging owners was a primary consideration in the sale of the company. . . . Some bad legislation in the form of gift taxes, death duties and capital gains taxes sometimes puts extreme pressure upon a family business to sell out . . . [leading to the conclusion] that the basic reason for the merger and sale of seed companies has been due to the U.S. tax laws" (Seed Trade News, 1980, p. 13). While this may explain why some seed companies are sold, it does not offer any explanation of why they are purchased. Although the latter reason has been discussed by advocates of plant protection, there has been little, if any, discussion of the international capital flow question.

INDUSTRY STRUCTURE AND ECONOMIC CONCENTRATION

In an effort to clarify some of the arguments concerning economic concentration in the seed industry, the following section examines some aspects of the structure and concentration in the farm seed, farm pesticide, and fertilizer industries.

By looking at growth in expenditures and prices of related input industries, perhaps some light can be shed on the question of undue price enhancement in the seed industry. That is, arguments against plant patent legislation on the grounds that it leads to significantly higher seed prices can be more clearly evaluated if changes in seed prices and expenditures are seen in relation to changes in prices and expenditures of related input industries.

Farm Seed Industry. The farm seed industry has shown remarkable growth in recent years. Farmers spent an estimated \$3.6 billion for seeds and plants in 1980, more than triple the amount spent in 1971 (\$1.1 billion). Seed expenditures account for 4.1 percent of farmers' current operating expenditures and 2.8 percent of their total production costs (USDA, 1980b).

The market for seed corn is the only one for

which market share information is available. Two firms, Pioneer and Dekalb, have controlled about half of this market for several years—46 percent of the sales in 1979 and 45 percent in 1973. When the market shares of the next 6 leading firms are included, (Funk, Trojan Northrup-King, Golden Harvest, PAG, and Jacques) the 8 leading firms account for 69 percent of the market, a decline from 74 percent in 1973 (Miller, 1980). The annual market shares from 1973 to 1979 for the leading firms are shown in Table 2, and n-firm concentration ratios in Table 3.

From 1971 through 1975, expenditures for seeds and plants rose by 114 percent. For 1976 through 1980 (estimated), the increase is expected to be 57 percent. For the decade as a whole, expenditures for seeds will have increased 236 percent. The annual increase in expenditures for seeds from 1971 through 1980 is 13.6 percent.

If the rise in seed expenditures is due primarily to industry growth, then the charge that patents have led to higher seed prices is somewhat weakened. The tremendous rise in seed expenditures is not attributable to growth alone, however. More than half the increase in expenditures results from increases in seed prices. Therefore, changes in the structure of the seed industry may also be shown by examining data on seed prices (Table 4). While expenditures for all seeds rose 236 percent from 1971 to 1980, the price of hybrid corn during the same period rose 142 percent, winter wheat 177 percent, soybeans 146 percent, winter barley 116 percent, spring barley 205 percent, and sorghum 87 percent (USDA, 1979).

Farm Pesticides and Fertilizer. Farm pesticides (insecticides, herbicides, and fungicides), like seeds, account for a relatively small portion of total production costs—for 1980, 3.5 percent (\$2.8 billion) of current operating expenses and

TABLE 2. Market Shares for Corn of Leading Seed Companies, 1973–1979

Firm	1973	1974	1975	1976	1977	1978	1979
	Percent						
Pioneer	23.8	25.5	24.6	27.3	30.9	26.2	32.9
Dekalb	21.0	18.8	18.8	19.5	15.8	17.9	13.3
Funk	8.8	9.4	8.9	9.2	6.4	8.1	6.7
Trojan	5.9	5.1	6.8	5.6	4.2	5.4	3.8
Northrup-King	6.1	4.5	4.7	3.4	3.8	3.3	3.8
PAG	3.5	3.3	2.5	1.8	2.6	2.9	1.6
Golden Harvest	—	—	1.8	2.4	2.5	3.1	2.9
Jacques	—	1.3	1.7	2.0	1.9	2.1	2.7
Cargill	1.3	2.8	1.4	1.7	1.5	1.7	1.7

Source: *Miller Agrivertical Unit*, 1979 and 1980, (The Miller Publishing Company). Sample sizes varied from 25 to 33 percent of total corn acreage.

TABLE 3. Concentration Ratios for Seed Corn Industry, 1973-1979

Number of Firms	Market Share						
	1973	1974	1975	1976	1977	1978	1979
	Percent						
8	72.5	70.7	69.8	71.2	68.1	67.0	69.7
7	71.2	69.4	68.1	69.4	66.2	64.9	67.7
6	69.1	66.6	66.3	67.4	63.7	62.0	64.1
5	65.6	63.3	63.8	65.0	61.1	58.9	60.5
4	59.7	58.8	59.1	61.6	57.3	55.6	56.7
3	53.6	53.7	52.3	56.0	53.1	52.2	52.9
2	44.8	44.3	43.4	46.8	46.7	44.1	46.2

Source: *Miller Agrivertical Unit*, 1979 and 1980, (The Miller Publishing Company). Sample sizes varied from 25 to 33 percent of total corn acreage.

TABLE 4. Change in Seed Prices, 1971-80

Period	Hybrid Corn	Winter Wheat	Soybeans	Winter Barley	Spring Barley	Sorghum
	Percent					
1971 - 1972	20	5	21	10	2	5
1972 - 1973	14	11	7	15	5	5
1973 - 1974	3	142	68	60	18	6
1974 - 1975	13	4	9	15	74	16
1975 - 1976	46	(19) ^b	11	3	34	28
1976 - 1977	-0-	(2)	(30)	(9)	(7)	3
1977 - 1978	10	(27)	76	(13)	(10)	9
1978 - 1979	8	34	(12)	9	(11)	5
1979 - 1980 ^a	6	25	4	15	41	(5)
1971 - 80	142	177	146	116	205	87
Average Annual Change	10	17.8	13.3	9.5	14.4	6.8

^a estimated

^b () price reduction

Source: USDA, *Agricultural Statistics*, 1972 and 1979, Washington, D.C.

2.5 percent of total production costs (USDA, 1980a).

Expenditures for pesticides in the past ten years have nearly tripled, rising from \$1 billion in 1971 to \$2.8 billion in 1980. Most of this increase in expenditures occurred by 1975, however. In fact, expenditures in 1976 decreased by almost \$1 billion from 1975. Nearly all of the increase in expenditures is due to higher prices, even though price rises have been slight over the past 5 years. While expenditures increased 179 percent over the decade, the average prices of insecticides rose 105 percent, fungicides 200 percent, and herbicides 53 percent.

There are approximately 50 firms that produce pesticides; 4 of these firms account for 50 percent of the market. For herbicides, the 4 leading firms have 71 percent of the sales, and for insecticides, the 4 leading firms have 46 percent of the market (USDA, 1980a).

Expenditures for fertilizers have risen dramatically since 1971, from \$2.4 billion to \$8.3 billion (estimated) in 1980. As with pesticides, most of the increase in expenditures occurred from 1971

to 1975. However, expenditures for 1980 are expected to increase 25 percent over 1979.

The growth of this industry can also be attributed almost totally to price increases. From 1971 to 1975, increases in the price of fertilizer ranged from a low of 55 percent for limestone, to a high of 347 percent for superphosphate. From 1975 to 1978, fertilizer prices fell—the largest decrease was for nitrogen 28, a 31 percent decline, while potash prices decreased only 6 percent. Overall, from 1971 to 1978, fertilizer prices doubled, while expenditures increased by 140 percent.

Most fertilizer companies are owned by large, diversified corporations, several of whom are major chemical or oil companies. Within the fertilizer industry, the phosphate industry is the most heavily concentrated, while the nitrogen industry is the least concentrated (USDA, 1980a).

What can be concluded from this brief review of the structure of these 3 input industries? The data do not suggest that increased concentration has occurred. While expenditures for seeds have tripled over the decade, so have expenditures for pesticides and fertilizers. In fact, all 3 industries demonstrate parallel and relatively comparable changes in sales growth and price increases. And, there is no known evidence of collusion; rather, changes in fundamental conditions perhaps explain the increases. The leading pesticide and fertilizer industries are not involved in the seed industry, except in one instance. The Ciba-Geigy Corporation, which holds the leading market position in herbicide sales, also owns three seed companies. One of its seed companies, Funk Seeds International, has been the third leading seed company since 1973. Otherwise, the chemical companies involved in seed development are apparently not involved in the pesticide and fertilizer industries.

While this cursory examination would suggest that the issuance of patents to seed companies since 1971 does not appear to have significantly influenced market position or prices, additional research is needed for a more conclusive determination. If expenditures for seeds are traced back another 10 years to 1960, changes in expenditures of much smaller magnitudes can be observed.

There are a number of economic factors that may have jointly contributed to the increase in seed prices from 1960 to the present. Patents provide a protected market which may be a reason for the acquisition of seed companies by large, diversified corporations. The possibility of patent legislation first arose in 1961; maybe because seed companies appeared to be an attractive investment providing a good return by patent protection. The energy crisis in the early 1970s caused a major disruption in the economy. Seeds would be somewhat affected by skyrocketing energy prices insofar as resins, coating, and pel-

leting of seeds are affected. Additionally, with seed companies owned by petrochemical corporations, to what extent can energy costs be internalized and these costs passed on to subsidiary seed companies? Finally, since patents do offer protection, it may be argued that the seed industry might be markedly different without the PVPA. Without PVPA, would there have been acquisition of seed companies? Without acquisitions, what kinds of growth and increases in prices might have occurred? Would market share positions be the same?

Even answering these questions would not answer the question of desirability of plant patent legislation. Is the performance of a protected market more or less desirable than a market functioning without patent protection? In other words, is the market, with PVPA, doing a better job of providing society the amount, kind, and quality of food desired?

GENETIC VARIABILITY

A central element in this issue is the role of the PVPA as a cause of the loss of genetic variability. Is genetic variability decreasing and, if so, is this a significant threat to our food supply?

Various crop characteristics considered desirable by farmers, marketing agents, food retailers, and consumers converge to delimit the search by plant breeders for parent materials. Only a few varieties are likely to possess the desired characteristics at any particular point in time. Thus, meeting the demands of society for more, better, and less costly food and fiber inevitably decreases the genetic base of a crop. As seeds become more uniform to meet these demands, this may, in turn, increase crop vulnerability to pests and disease. The National Academy of Sciences has aptly described this situation:

“Clearly the market wants uniformity. If one breeder or one farmer fails to provide it, the market will turn to another that will . . . the market is just as insistent on cost as on uniformity. The market wants to pay the lowest price. If one farmer cannot sell it for a price, another will.

Demands for efficiency are really demands for uniformity in a different guise. The farmer must have high-yielding varieties. Because the low-yielding members of the plant population have been eliminated, this too means uniformity. The farmer must substitute machines for men, but machines can't think, again varieties must be uniform. . . .

Seeds are sown by machines. These too must be uniform or they move unevenly

TABLE 5. Acreage, Value, and Varietal Variation of Major Crops, 1969

Crop	Acreage (millions)	Value (million \$)	Total Varieties	Major Varieties	Acreage to Major Varieties (Percent)
Bean, dry	1.4	143	25	2	60
Bean, snap	0.3	99	70	3	76
Cotton	11.2	1,200	50	3	53
Corn ^a	66.3	5,200	197 ^b	6	71
Millet	2.0	NA	NA	3	100
Peanut	1.4	312	15	9	95
Peas	0.4	80	50	2	96
Potato	1.4	616	82	4	72
Rice	1.8	449	14	4	65
Sorghum	16.8	795	NA	NA	NA
Soybean	42.4	2,500	62	6	56
Sugar beet	1.4	367	16	2	42
Sweet potato	0.13	63	48	1	69
Wheat	44.3	1,800	269	9	50

^a Corn includes seeds, forage, and silage.

^b released public inbreds only.

NA = Not available.

Source: National Academy of Sciences, *Genetic Vulnerability of Major Crops*, 1972.

and inefficiently through the planter. The seeds must germinate and grow simultaneously, or they leave space for weeds to grow in the row where the cultivating machine must go. . . .

Crops must be uniform for harvesting. Tomatoes, peas, and potatoes must ripen at the same time if they are to be machine harvested because the machine cannot distinguish between a green tomato and a ripe one. . . . And so it goes, uniformity—always uniformity” (National Academy, 1972, p. 289).

There is some evidence that genetic losses have occurred and are continuing to occur—the question is whether or not the *rate* of genetic loss is tolerable and if PVPA has influenced this rate. The narrow varietal base for the major field crops is suggested by the following and by the data in Table 5: (1) 71 percent of the nation's corn acreage depends on just 6 varieties; (2) the 1970 corn blight destroyed nearly one-fifth of the crop that year; (3) wheat stem rust took 65 percent of the Durum wheat in 1953 and 75 percent in 1954, and 25 percent of the bread wheat crop in 1954; (4) 40 percent of the hard red winter wheat acreage is dependent on only 2 varieties and their derivatives; and (5) soybeans consist of only 6 major varieties.

Society must be willing to trade off some amount of genetic diversity in order to have more, better, and less costly food and fiber. Intelligent decisions on the desired extent of the trade-off requires information on the costs and benefits involved. The benefits of uniformity are, as described above, efficiency in production, yield, attractive food, and reasonable prices. All these factors give consumers a choice in the market—the ability to choose from an abundant supply, in a competitive market, at reasonable prices.

Ironically, opponents of plant variety protection fear that the very attributes that society desires to maximize may result in choices actually becoming more limited because of the inherent risks of uniformity. In other words, society desires some degree of uniformity for the benefits it provides; but, after some point, uniformity could result in decreased or more uncertain benefits. Opponents of plant protection argue that the extent of uniformity is dangerous. In simple terms, the opponents feel that the marginal cost of monoculturing is increasing relative to the marginal benefits derived. Furthermore, they perceive plant protection legislation as a contributing factor toward increasing this cost/benefit ratio. On the other hand, advocates are cognizant of the problems and risks incurred by a loss of genetic diversity; but they perceive plant protection legislation as a beneficial contribution. That is, the marginal benefit of patents is greater than the marginal cost or risk involved. As the Executive Vice-President of ASTA Dr. Harold Loden perceives the situation: "Farmers want to grow the variety that makes the highest yield. Seedsmen and breeders produce and sell the best variety possible. Why should anyone, including a poor farmer, be burdened with the responsibility of growing inferior varieties to maintain genetic diversity at the expense of higher yield to his family and others" (*Seed Trade News*, 1980, p. 15).

Advocates of plant protection feel that the issue of genetic variability will arise irrespective of the PVPA and that it can be resolved even with such legislation. Again, a view of ASTA: "Genetic diversity and variability are preserved in germplasm⁵ banks throughout the world, (in) seed storage laboratories, in genetic stocks preserved by seed companies, (and in) seeds saved by farmers for their own use (which is permitted by the PVPA) as well as (in) a reservoir of genetic diversity in the wild. There is even a genetic variation in so-called "finished" varieties that will respond and become visible with changes in

environmental pressure" (*Seed Trade News*, 1980, p. 15).

The research needed to help society choose between these polar positions is obvious.

SUMMARY

That such a seemingly inconsequential bill as the amendments to the PVPA could arouse so much controversy and debate is illustrative of the complexities involved in the policy process. The apparent intent of the PVPA and the proposed amendments is to increase the research in the private sector by offering publicly granted economic incentives—patents. The degree of success of this approach has produced most of the debate. Some opponents have also questioned the intent, fearing a diminution of publicly funded research.

Two conclusions seem to emerge. The first is that a definitive or quick resolution is unlikely, despite passage of the amendments by the Congress. As global food needs continue to increase, as concern for nutrition as well as abundance of food supply increases, and as environmental concerns demand more attention, policies directly and indirectly (such as genetic variability) affecting the food supply will be more controversial issues.

The second conclusion is that a comprehensive study of the several aspects of this issue is suggested in order to address the primary questions raised by the Plant Variety Protection Act. Chief Justice Burger stated that it is incumbent upon the legislative bodies to undertake the kind of investigation and examination demanded by these issues that the Court is incapable of providing. In fact, the Senate Agriculture Committee requested, and the Department of Agriculture is currently providing, a study to provide some clear indication of the impact of this legislation on both the seed industry and society.

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⁵ Germplasm is the material located in the cell that determines the traits of plants and animals; that is, the genes located on the chromosomes.

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