EFFECTS OF THE 1970 PLANT VARIETY PROTECTION ACT

Richard K. Perrin
K. Adrian Hunnings
Loren A. Ihnen

Richard K. Perrin and Loren A. Ihnen are professors of economics and business, N.C. State University. Adrian Hunnings, formerly a research associate at N.C. State University, is employed with the National Cotton Council of America. The research on which this paper is based was supported by the North Carolina Agricultural Research Service. The authors acknowledge valuable comments from Tom Johnson, Charles Knoeber, Foil McLaughlin, and other colleagues.

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SOME EFFECTS OF THE U. S. PLANT VARIETY PROTECTION ACT OF 1970

The 1970 Plant Variety Protection Act (PVPA) established patent-like property rights which vest in the owner of a protected variety limited rights to exclude others from reproducing or selling the variety. Nearly thirty other countries have established some form of breeders rights, but it has been only recently that the desirability of such rights has been seriously challenged - especially in the U. S. as amendments have been considered, and in Australia and Canada as legislative authority for such rights has been debated. The challenges have been related to the possible effects of breeders' rights on firm concentration in the breeding industry, on the genetic diversity of crop varieties, and on the free exchange of breeding materials among breeders. (See Barton, Claffey, Godden and Powell, and Bradnock for discussions of these issues.)

Apart from the validity of objections to breeders' rights, it is of interest to examine the potential merits of the Act. The stated purpose of the legislation was to increase the incentives for private investment in plant breeding, and thereby to increase the rate of growth of agricultural productivity. This paper examines these incentives and some evidence related to the extent of private plant breeding and the rate of yield improvements from soybean breeding efforts.

PLANT BREEDERS' INCENTIVES

The breeding of commercial plants as an economic activity has much in common with other inventive activity. The potential rewards to society can be enormous for even modest improvements in productivity, but the probabilities for achieving such improvements are not great, the pay-

off period cannot begin until many years after the beginning of the breeding activity, and the breeder may not be able to appropriate much if any of the economic gains ultimately realized. Because of these similarities, one might expect that patent rights would have been extended to plant breeders, but this has not been the case.[1]

Despite these disincentives, there has developed in the U. S. a large and vigorous industry devoted to the breeding and sale of corn and sorghum hybrids. There has been no similar scale of activity in the breeding of major field crops which are grown as varieties, as opposed to hybrids.[2] The incentives for breeding varieties and hybrids differ because seeds for varieties are essentially durables, while seeds for hybrids are in essence non-durables. A variety is a unique population of plants which is uniform from plant to plant, and which will "breed true", producing similar plants from generation to generation. Amongst commercial grain crops, the term hybrid refers to the first generation (F_1) plants resulting from the cross of two very carefully selected varieties. These F_1 plants exhibit uniformity from plant to plant, and a hybrid vigor known as heterosis, but the subsequent generation (the F_2) exhibits neither. Thus a farmer who wishes to plant the same genetic stuff in a succeeding year can save some of his first year crop for seed if he has planted a variety (the genetic material is a durable), but he must return again to the source if he has planted a hybrid (the genetic material is not a durable).

The significance of durability for the incentives for breeders of varieties is as described by Coase in his analysis of durability and monopoly. The monopolist producer of a durable good (plant breeder in our case) desires to set a price which equates marginal revenue and marginal cost of production in the first sales period. The returns in ex-

cess of production costs are current economic rents which provide the reward and incentive for the earlier inventive activity. In the second sales period, the monopolist observes there is opportunity for realizing additional rents by lowering the price for customers who did not purchase in the first period. He apparently has the opportunity to reduce his price each year (price discriminate through time) until his price falls to the level of his marginal costs, at which point no further rents are to be realized. But if buyers are aware of these incentives to reduce the price through time, the monopolist's opportunity to price discriminate is only apparent, since the buyers will postpone their purchase in anticipation of the reduced price.

This consequence of durability may severely limit the incentives for a breeder to develop new varieties. Add to this the fact that the genetic material in a variety is not only a durable, but a fecund durable. A farmer who purchases seed for a new wheat variety may produce that crop for any of several purposes, but the entire crop contains the genetic material and could be used as seed by other farmers as well as by the producing farmer. This fecundity is further reason for farmers to expect low prices for the seed in the future, and thus a further erosion of expected returns to the breeder from developing the variety. In contrast, the breeder of a superior hybrid can anticipate pricing his seed so as to realize some rents each year, confident that his customers will not become his competitors in succeeding years.

Plant breeders as early as Luther Burbank[3] have been concerned that some form of breeders' rights be established to increase the incentives for what appears to be an activity with high social payoffs but low returns to the breeder. The Plant Patent Act of 1930 permitted the patent-

ing only of asexually propagated species, and thus had no impact on commercial crop breeding. It took another forty years for the U. S. Congress to agree on legislation which established breeders' rights outside the regular patent system. The Plant Variety Protection Act of 1970 (PVPA) was enacted with little public fanfare, but by 1980 breeders' rights had become more of an environmental and international issue,[4] and some technical amendments to the Act provided the occasion for some vigorous debate of the desirability of the Act (U. S. Congress, 1980).

Some significant features of the PVPA are as follows.

Rights conferred. The owner of a protected variety has the right to exclude others from selling, reproducing, importing or exporting the variety for a period of 18 years. (Sections 83, 111).

Exceptions: It is not an infringement of these rights to:

a) save seed for use on the producer's farm (Section 113) or

b) use and reproduce a protected variety for plant breeding or other bona fide research (Section 114).

Limitation: If an owner does not supply "public needs" for the variety at a "fair" price, the Secretary of Agriculture may declare the variety open to public use (with "equitable remuneration" to the owner) if this is necessary to insure an adequate supply of food and fiber (Section 44).

Assignment of rights by owner. Plant protection has the attributes of personal property, and the rights may be transferred by sale or licensing (Section 101).

Remedy for Infringement of rights. Remedy for infringement is by civil action for damages.

Eligibility of varieties for protection. To be eligible, a variety must have these properties:

a) Distinctness in some identifiable characteristics from all prior varieties of public knowledge,

b) Uniformity in the sense that any variations are describable, predictable and commercially acceptable, and

c) Stability when sexually reproduced, in terms of retaining distinctive characteristics (Section 41).

Establishment of eligibility. The breeder's description of the variety is sufficient to establish that the eligibility criteria are met. No government agency field trials are necessary.

Exempted plants. Section 144 exempted okra, celery, peppers, tomatoes, carrots and cucumbers, but these exemptions were repealed in 1980. Section 42 exempts first generation hybrids, fungi and bacteria.

Repository seed samples. Section 52 and subsequent regulations require that a sample of 2,500 viable seeds must be deposited with the application.

In considering the effect of the PVPA on breeders' incentives, it is important to notice that the provisions do not offset the Coase durability obstacle to the appropriation of rents by the owner of a protected variety. The Act is intended only to offset the fecundity feature of the genetic durable, but some reflection suggests that it will be only partially successful. In the first place, the law does not prohibit a farmer from purchasing a small amount of seed and multiplying it himself to provide seed for his entire acreage in the second year. Thus the customer is still a potential competitor of the breeder in supplying the durable to himself.

Furthermore, it seems likely that it will be difficult and expensive for the breeder to enforce the prohibition against the customer becoming a competitor in supplying his neighbors and other farmers with the variety. The original customer could become an unwitting competitor to the extent that his grain crop could be pirated for seed once it enters normal commercial grain marketing channels.

Thus it seems unlikely that the PVPA will increase substantially the rewards to breeders. Certainly the potential for rewards to the breeder of a protected variety cannot be expected to approach the rewards to the breeders of a comparably superior hybrid. Despite the pessimism of this analysis, it is possible that private breeding firms have anticipated increased incentives for breeding of varieties. If so, one might first expect to observe an increase in private investment in breeding of the non-hybrid crops, than an increase in the number of varieties available to farmers, and ultimately an increase in the rate of change in productivity of the crop sector. We now turn to some empirical evidence pertaining to these possible effects of the PVPA.

PRIVATE INVESTMENT IN PLANT BREEDING, 1960 - 1979

If the 1970 PVPA were to have any impact on private investment in plant breeding, some effect should have been apparent by 1980. White has previously conducted a survey of firms which suggested that the PVPA was indeed a stimulus to plant breeding research. To explore this further we conducted a mail survey in the summer of 1980 of 214 seed firms, requesting value of sales and expenditures on breeding programs between 1960 and 1979 (see Perrin, Hunnings and Ihnen for detail). Based on our estimates of the value of seed planted in the U.S. in 1979,

our estimates of the fraction of seed provided by the firms in our sample range from 4.5% of the seed for cereal crops to nearly two-thirds of the corn seed and essentially all of the sorghum seed.

Expenditures on crop breeding, as reported by 59 firms with complete reports, increased dramatically between 1960 and 1979 (Table 1), as did the number of breeding programs. These increases are substantial even when corrected for inflation. We should note here that these increases are upward-biased estimates of the increases in total U.S. private breeding expenditures, because our sample frame did not include breeding firms which had ceased to exist by 1980, and we thus under-estimate expenditures in the earlier years by an unknown amount. These data are consistent with the hypothesis that the 1970 PVPA increased private investment in the breeding of non-hybrid crops (cereals, forages and especially soybeans). The rate of increase in expenditures on these crops has exceeded that for hybrid sorghums since 1970, but has fallen short of the rate of increase in breeding expenditures for hybrid corn. It is clear that factors other than the PVPA have also been important in determining private breeding activity, but it has been beyond the scope of this study to determine what those factors are and to distinguish their effects from those of the PVPA.

PLANT VARIETY PROTECTION AND SOYBEAN VARIETY IMPROVEMENT

Private investment in soybean breeding has been especially affected by the PVPA, as indicated by the survey results, by the fact that some 244 soybean protection certificates had been issued by 1983 (Evenson, Table 2), and by the fact that some 46% of soybean area was planted to post-1971 varieties by 1982 (Evenson, Table 3). In this section we

examine the trend in productivity of new varieties, before and after the PVPA. To do this we have examined the results of variety test trials between 1960 and 1979 in Iowa, Louisiana and North Carolina (see Perrin, Hunnings and Ihnen for details).

The 586 variety entries which had been tested included commercially available varieties, brands or blends of varieties, and also some advanced breeding lines not yet commercially available. Only 56 of the entries were protected varieties, something less than half of the total number of varieties for which certificates had been issued by 1979. In 1964, the first year for which data were available from all three states, only 32 entries were being tested, whereas by 1978 some 140 were being tested each year. Overall average yields of varieties grouped by vintage year (the year the variety was released or first appeared in the test) increased from 36.6 bushels per acre for varieties released during or prior to 1948 up to 50.7 bushels per acre for the 55 varieties of 1975 vintage.

To establish in a preliminary way the trend in variety improvement more clearly, we have regressed yields on a spliced function of vintage year, with the splice at 1970. In this regression the effects of test year and location are held constant with dummy variables. The estimated regression equation is

$$\underset{\quad}{\text{Yield}} = \underset{(10.9)}{41.1} - \underset{(-0.6)}{0.35}\ \text{PRE71} + \underset{(1.4)}{0.117}\ \text{POST70} + \text{dummy effects},$$

With $R^2 = 0.39$, N = 2755, t-ratios shown in parentheses, and

$$\text{PRE71} = \begin{cases} \text{vintage}, & \text{if vintage} \leq 1970, \text{ and} \\ 1970, & \text{if vintage} > 1970 \end{cases}$$

$$\text{POST70} = \begin{cases} 0 & \text{if vintage} \leq 1970, \text{ and} \\ \text{vintage} - 1970, & \text{if vintage} > 1970. \end{cases}$$

The coefficients for the 19 year dummy variable and 5 area dummy variables are reported elsewhere (Perrin, et.al., Table 8).

These regression results indicate that there was essentially no trend in the yields of varieties released in successive years prior to 1970 (-.035) bu per acre per year), while there was a positive trend of 0.12 bushels per acre per year improvement in varieties released since then. The low t-ratio of 1.4 indicates that this latter trend is significant only at the 16% confidence level, but the result is certainly consistent with the hypothesis that the PVPA has increased the rate of improvement in soybean varieties. While the statistical significance of this test is weak, it is a very conservative test of the hypothesis that genetic progress has been more rapid since 1970, simply because we have included all tested varieties in the analysis, whereas farmers will only select the most productive of these varieties for commercial use. An improvement rate of 0.12 bushels of yield per year may seem small, but if it were realized on the entire U.S. soybean crop, the value of the annual increase would amount to some $50 million (70 million acres times .12 bushels times $6.00 per bushel), or $500 million annually after ten years of improvement.

CONCLUSIONS AND IMPLICATIONS

This study set about to examine some of the effects of the 1970 Plant Variety Protection Act. Our theoretical consideration of the seed market suggests that the increased rewards and incentives for breeders may be quite small because of the durable nature of variety seeds and the difficulties of policing the limited rights which are granted to owners of protected varieties. We nonetheless found from a survey of plant breeding firms that private investments in breeding non-hybrid crops

increased more rapidly during the decade after the 1970 Act than during the previous decade. The number of breeding programs in soybeans and cereals grew from only a half dozen in the early 1960's to about 30 in the late 1970's, and research expenditures grew from essentially zero in 1960 to about $8.5 million by 1979. While these results are consistent with the hypothesis that PVPA has increased breeding activity, other factors were obviously of importance, since investments in hybrid corn breeding (not directly affected by the Act) increased just as dramatically in the second period, while investments in hybrid sorghum showed little deviation from trend.

Our examination of university-sponsored soybean variety test trials in three states showed that the number of varieties being tested grew from about thirty during the early 1960's to nearly 150 in the late 1970's, offering further evidence of the possible effects of the Act on soybean breeding. An analysis of the yields in these tests indicates that after 1970 the new varieties released each year yielded about 0.12 bushels per acre more than the varieties released in the previous year, versus no trend at all in the yields of new varieties released in successive years prior to 1970. Thus, while agricultural productivity has probably not yet been significantly affected by the recent increase in soybean breeding activity, it is likely that soybean productivity will be affected as farmers adopt these new varieties.

Taken together, this study suggests that the Act may well be having its intended objectives of increasing agricultural productivity through increased incentives for private plant breeding research. Additional studies will be required before this conclusion can be held with confidence.

Some other important issues related to the desirability of the Act, such as its effects on firm concentration in the breeding industry, on the genetic diversity of crop varieties, and on the exchange of breeding materials among breeders, were beyond the scope of the study.

Table 1. Crop breeding research expenditures reported by 59 firms[a]

Crop	1960	1965	1970	1975	1979
			(current $ thousand)		
Hybrid corn	1,873	2,710	4,913	10,217	19,745
	(14)	(14)	(18)	(26)	(32)
Hybrid sorghum	448	662	1,202	1,736	2,847
	(6)	(8)	(12)	(17)	(18)
Soybeans	2	33	270	2,069	4,296
	(1)	(4)	(8)	(19)	(21)
Cereals	8	294	1,083	3,112	4,328
	(1)	(3)	(6)	(9)	(9)
Forage and turf grasses	256	572	1,077	1,805	3,049
	(4)	(7)	(9)	(14)	(16)
Vegetables	977	1,406	2,522	4,217	7,517
	(7)	(8)	(12)	(11)	(16)
Other crops	8	24	226	992	878
	(1)	(3)	(6)	(7)	(11)
Total	3,572	5,707	11,293	24,148	42,630

[a]Numbers in parentheses are numbers of firms with breeding programs for the crop specified. Only the 59 firms able to provide information for the full 1960-1979 period were included in this tabulation.

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FOOTNOTES

[1]Exceptions are asexually reproduced plants, which are patentable under the Plant Patent Act of 1930.

[2]To date, commercial success in hybrids has been limited to corn and sorghum among major crops because of difficulties in other species of large scale cross breeding.

[3]Cited in U.S. Congress, 1930, p. 2.

[4]Efforts of breeders in Europe had led to the 1961 treaty creating the International Union for the Protection of New Plant Varieties, commonly referred to as UPOV, of which the U.S. is now a member. Some 30 countries altogether have some form of breeders' rights.