The political economy of hybrid corn

Marxist geneticist Richard Lewontin and economist Jean-Pierre Berlan discuss the economics of and role of capital in the production of hybrid corn. This article follows their 'Technology, research, and the penetration of capital: the case of U.S. agriculture' article.


"[In a commodity,] there is a definite social relation between men, that assumes, in their eyes, the fantastic form of a relation between things. In order, therefore, to find an analogy, we must have recourse to the mist enveloped regions of the religious world. In that world, the productions of the human brain appear as independent beings endowed with life, and entering into relation both with one another and the human race. So it is in the world of commodities with the product of men's hands. This I call the Fetishism which attaches itself to the products of labor, so soon as they are produced as commodities, and which is therefore inseparable from the production of commodities.” (Capital, Vol. 1, Ch. 1, Sect. 4)

The previous article provided an overview of how science and technology have been used to subordinate the largely pre-capitalist system of agricultural production to the domination of capital. In this article we provide a case study of the penetration of capital in corn cultivation with the spread of the use of hybrid corn, the flagship of the successful innovations of twentieth-century agricultural research. Geneticists, historians, sociologists, and economists have cited it as a prime example of the enormous yield increases derived from basic research motivated only by the quest for knowledge. Moreover, economists have made extravagant claims about the reaping of social—and only social—benefits from this innovation.

These claims are myths, as will soon become clear. Before 1910 farmers improved their corn crop by selecting the best ears of corn in their fields for use as seed for next year's crop. The breeding of new varieties focused on the selection of "show" corn that was most marketable. But selecting only on the basis of appearance led to decreasing yields. Around 1910 a new method of breeding--hybridization--was invented that seemed to develop higher-yielding varieties. Before long research efforts and government finance for research were channeled into work on hybrid seeds. All other research efforts were in effect abandoned. The new technique was widely touted as a revolutionary breakthrough based on a new theoretical discovery, and the use of hybrid corn seed grew from 13 percent in 1937 to 88 percent in 1945.

Behind this transformation, however, lay not only a new technology but vital commercial interests. If farmers save seed grown from an initial purchase of a hybrid variety, yields decrease precipitously in the following year. Thus, once farmers turned to planting hybrid corn they had to buy seed from a commercial seed producer every year instead of picking, at harvest time, the healthy and productive ears from their own corn fields for next year's seed, as they had always done. In other words, the adoption of hybrid corn transformed seed into a commodity.

As the use of hybrid seed spread, the mass production of hybrid seed became a highly profitable growth industry. The combination of commercial interest and substantial government support in aid of improved hybrid seed led to the dominance of a new type of seed-corn production and marketing. Not least among the reasons for the successful marketing of the new technology was the spread of an ideology and of dubious claims that rationalized its effectiveness.

The agricultural establishment has consistently made two claims: (a) that hybrids increased yields; and (b) that the margin of increase was large. What is submitted in support of these two claims, however, is wholly unreliable. Before looking into the presumed evidence, it is important to understand that there occurred more or less simultaneously a number of developments that contributed in one way or another to higher yields: (1) The
introduction of a planned program of plant breeding. The confusion of breeding, in general, with hybridity as a particular method (see box, p. 42) is fundamental. (2) An unprecedented effort by government agencies to develop improved varieties in support of the hybrid-seed strategy. (3) Changes in cultivation techniques, such as crop rotation, increased use of fertilizers, and mechanization. (4) Introduction of more efficient experimental and statistical test procedures. Although the agricultural establishment is well aware that all these changes played a role, they nevertheless attribute the increase in yields primarily to the use of hybrid seeds and do not distinguish between the effect of hybrids and the other contributing factors.

The concentration of hybridization as the primary, if not the sole, cause was part of the commoditization process. A typical example of the carelessness of scientists on this matter is the following claim made in the 1976 monumental work on corn breeding by Juggenheimer: "Conservative estimates indicate that hybrid seed has increased production in the United States from 25 to 50 percent." Three references support his claim. One is his own 1958 book where the same claim is made without any reference; the second comes from an Assistant Secretary of Agriculture who again gives no references. The third comes from a book where the reference is again that same Assistant Secretary!

Except for early figures derived from the carefully planned Iowa Corn Yield Test showing a 7-11 percent increase in hybrid yields, we do not know when, where, how, or by whom the experiments to support these claims were performed. In any case, all such comparisons would be fallacious. Before the 1920s, corn breeding was corn show breeding, i.e., breeding for the best looking ears, which failed to produce even average crops and led to an actual decrease of yields. Starting in 1921, public and private research was focused exclusively on hybrid breeding so that it is difficult to retrospect to sort out how much improvement was due to hybrids and how much was due to an unprecedented public breeding effort.

To circumvent this difficulty, breeders have offered statistical evidence such as comparison of the evolution of corn yields with the yields of crops that did not benefit from hybridity. Graph 1 is typical. One can see both the huge surge of corn yields concomitant with the spread of hybrids, and that such a surge did not occur for a non-hybrid species such as tame hay. However, tame hay does not offer a valid comparison. It was hardly a commercial crop, yields were difficult to measure, and breeding attempts on this crop were limited. A more valid comparison is with wheat, a non-hybrid commercial crop whose improvement has been actively pursued all over the United States.

Comparison of corn and wheat yields destroys the claim of a special yield increase due to hybridity. During the period 1937-1945, when the acreage sown to hybrids increased rapidly in the Corn Belt, wheat yields increased at 4.4 percent per year, while corn yields increased only 2.8 percent per year. Furthermore, the comparison neglects important changes in mechanization, crop rotation, fertilizers, economic policies, etc., that had an important bearing on yields of cash crops. Lastly, from the mid-1920s on, there was a development of efficient experimental Fisher's immensely influential book, Statistical Methods for Research Workers, was published in 1925).

The apparently apolitical, value-free, objective claim that hybrids (or hybridity) increased yields is a reification of a product of the human mind that was necessary for the creation of a new and immensely profitable commodity. In Marx's words, breeding created "a definite social relation between man, that assumed, in their eyes, the fantastic form of a relation between things."

The Theoretical Evidence

Hybrid vigor in the strict biological sense of superiority of a corn hybrid over its genetically inbred parents is a general natural phenomenon. In that sense, hybrids or hybridity do increase yield. But it is a far cry from this natural phenomenon to claim that hybridity per se accounted for the superiority of particular hybrid combinations of inbred lines over the open-pollinated varieties of corn that farmers grew before the hybrid corn era. Two
theoretical explanations for hybrid vigor were offered almost simultaneously in 1909 and 1910. Both explanations were able to account for two experimental phenomena: the decrease in vigor during inbreeding, and the recovery of vigor in the cross of two inbred lines. The two explanations, however, had opposite consequences for the best choice of a breeding technique.

The first explanation claimed that hybrid vigor was due to hybridity per se. It was proposed (or rather imposed) by two American geneticists, East and Shull, after they invented, on purely empirical grounds, what they thought was a "revolutionary" breeding method, the inbred-hybrid technique. They justified their invention by the claim that hybrids benefited from a "physiological stimulation" due to hybridity per se—the fact of carrying pairs of unlike genes. But they did not offer any evidence to support their theory. The physiological stimulation was just another name for the phenomenon and not an explanation.

The second explanation was put forward by British geneticists who had no stake in the matter, since no corn was then grown in England. It stuck to the initial Mendelian model of heredity and stated that hybrid vigor was due to the "covering-up" of unfavorable genes by their favorable counterparts—Mendel's so-called "law of dominance."

Both models predicted that inbreeding should reduce yield, and crossing inbred lines should increase it. However, the East-Shull explanation had another consequence and a crucial one: no improvement by selection was possible. Selection of the most vigorous plants in the traditional way would mean the selection of plants with a large number of pairs of unlike genes, according to their explanation of hybrid vigor. But, random crossing among these plants would break up the pairs of unlike genes into pairs of like genes, leading to a loss of vigor. Consequently, the theoretical view precluded all corn improvement techniques that relied on selection. Only the "revolutionary" inbred-hybrid technique that East and Shull had invented could lead to an improvement of the corn crop. This explanation was all the more plausible because earlier corn selection had failed—but it had failed because it was a selection for beauty, not for yield. Why is it, then, that corn breeding had become a beauty contest? It stemmed from the contradiction between breeding for use value, that is to improve efficiency in the production of agricultural commodities, and breeding as a commodity by itself (i.e., exchange value) as a profitable field for entrepreneurs. This second aspect came to dominate the corn shows. Commercial breeders bred for specific identifiable traits because it was what they could sell. Farmers then bought seed corn having "beautiful" features, thinking that it guaranteed higher yields.

On the other hand, the Mendelian model meant that the task of a breeder was to increase the number of favorable genes in a corn field. Selection was possible and indeed necessary. Farmers or breeders could scout their corn fields for the best plants and ears, could grow the seed together in order to reshuffle their genes, and could start the process all over again. In theory then, this common practice of mass selection ultimately increased the proportion of "good" genes and consequently led to a gradual improvement of the population of each cycle of selection through an increase in the frequency of favorable genes.

The consequence of this form of selection would be the creation of a self-perpetuating superior variety that could be harvested for next year's seed by the farmer himself in his own field of corn.

Practical Problems

East and Shull's proposal to breed hybrids because of physiological stimulation led to difficulties in practice. First, if vigor in hybrids is dependent upon the proportion of pairs of unlike genes, it could well be that the worst inbred lines would give highly productive hybrid combinations. There is no way to know in advance. The consequence, then, was a method of breeding that searched with no logical rule for rare superior combinations. A successful inbred-hybrid program required vast expenditures because the larger the sample of inbred lines combined into hybrids, the greater the likelihood of discovering, by chance, superior combinations. But, for cost
reasons, the sample had to be very small. Thus the expected payoff was low as compared with a Mendelian selection scheme.

Further difficulties arose because the inbred plants used in the cross to produce the hybrid seed are so depressed in vigor that they are inefficient seed producers. The solution to seed production was the invention by D. F. Jones of the double-cross in which the seed-producing plant itself is a hybrid, that is, a plant that has recovered vigor and that produces seed in large quantities. The commercial hybrid seeds are combinations of four lines in a two-stage crossing procedure. But this worsens the original problem. With only 20 lines (in the 30s, corn breeders produced thousands of lines), it is possible to get 190 single-crosses that can be tested (but their seed cannot be commercially produced) and close to 15,000 double-cross hybrids (the seeds of which could be commercially produced but would be too costly to test).

After 15 years of hard work beginning in 1921, the 52 hybrid corn breeders of the North-Central states achieved hybrid varieties that were less than 10 percent better than the open-pollinated varieties. And this modest result was attained only because breeders had, so to speak, cheated: they did select during the inbreeding process, keeping the better looking and the more productive material. That is, in practice, they accumulated the good genes in their inbred lines, while allegedly doing something else.

It is amazing that agricultural research would implement a breeding method that required such a huge investment in manpower, time, and money; that would not yield results for at least 10 years; and that rested on the random and blind manipulation of staggering numbers of plants while ignoring an alternative scheme which was simple, logical, and quick, i.e., mass selection of corn. As late as 1955, data on the effectiveness of mass selection of corn were almost completely lacking, and it is only recently that mass selection has been successfully implemented.

Still, the implementation of the expensive inbred-hybrid technique would be explicable if East and Shull's theory of hybrid stimulation had proven correct. Aside from the contradictions that plagued the practical implementation of such a theory and its ad hoc character, it has been known for more than 20 years that East and Shull's explanation for hybrid vigor was wrong and that the orthodox Mendelian explanation was correct! Why is it, then, that the U.S. Department of Agriculture has not yet launched a crash program of corn improvement through selection that could save farmers between one and two billion dollars a year?

Why Hybrid Corn?

Hybrid corn expanded the sphere of commodity production by creating a new and extraordinarily profitable commodity which could not have been produced by alternative breeding methods. In the early twentieth century, a strong social and ideological movement in favor of proprietary rights influenced breeding work. The relationship of hybridity to proprietary rights was explicitly known, and this relationship was decisive in the choice of the hybrid method in spite of the opposition of most scientists. Breeding work has a paradoxical nature--it is priceless in the two opposite meanings of the term: it has an immense social value like, say, a natural masterpiece, yet it has no market value, i.e., no price.

This pricelessness stems from the fundamental property of life, self-reproducibility. Biological production rests on genetic information, which is reproduced and multiplied in the production process. The farmer harvests in his field a seed that embodies the genetic information of the variety that he has sown and that he will sow.

At the turn of the century, American and European breeders became acutely aware of this economic contradiction. As early as 1885, private cereal and fruit breeders began calling for the establishment of a system of plant patents. In its first volume in 1910, the American Breeders Magazine deplored the paradox of those great breeders who died in poverty after bringing prosperity to entire areas:
Take, for instance Ephraim Bull, who gave the world the Concord grape, now a standard variety, cultivated in thousands of vineyards. He created wealth, luxury, refreshment and food for millions. Ephraim Bull died in poverty . . . and the passers-by are informed by the epitaph on the plain slab marking Ephraim Bull's grave: "HE SOWED, OTHERS REAPED."

In a bourgeois society, such a violation of property rights was the supreme injustice. Hybrids provided a solution. Indeed, Shull in his very first paper suggested that the problem of corn breeding "may possibly find a solution making it necessary to go back each year to the original combination, instead of selecting from among the hybrid offspring the stock for continued breeding." East and Jones wrote: "It (hybrids) is something that might easily be taken up by seedsmen; in fact, it is the first time in agricultural history that a seedsman is enabled to gain the full benefit from a desirable origination of his own or something that he has purchased."

In 1913 Henry Agard Wallace started a seed-corn business in Des Moines and got interested in the method that Shull and East had pioneered. His "shotgun approach" to inbred-hybrid breeding proved unfruitful, and Wallace realized that the technique was too complicated and costly to be developed by a single company. Only an all-out government effort would make it a reality.

In 1920 Warren Harding, President-elect of the United States, picked Henry C. Wallace, Henry A. Wallace's father, as Secretary of Agriculture. Before his nomination was official, he asked his son to report on the federal corn-breeding programs. Henry A. Wallace advised his father to get rid of traditional corn-breeding programs and to recruit new people to implement the new inbred-hybrid technique. These new recruits were former students of East at Harvard and of Emerson (who had himself worked with East) at Cornell. The funds going to hybrid-corn research were increased tenfold. Instead of the scattered, uncoordinated policies that had prevailed in the various experiment stations, a centralized "cooperative" hybrid-breeding program was begun, tightly coordinating the efforts of federal and state research under the direction of Frederick Richey.

Henry A. Wallace began in 1920 to preach the credo of the new corn that promised a revolution in American farming in the influential family weekly magazine, Wallace's Farmer. In 1924 he sold his first hybrid corn seed for $1 a pound. This hybrid seed corn won the 1924 Iowa corn-yield test in one of the southern sections of the state and was advertised as the revolutionary corn that a few lucky farmers could try for the first time. Wallace had gotten the parental lines from government supported breeding work: one line was from Connecticut Experiment Station and the other from Frederick Richey whom he had recommended to his father as the head of the federal corn-breeding program.

From his acre of seed corn grown under garden-like conditions (the hybrid was a single cross), he got about $840. The cost of producing the seed was probably lower than $100. This first sale encompassed the characteristic traits of the industry up to today: advertising to turn a public investment into private profit. The profits were enormous and, in 1926, Henry A. Wallace founded Pioneer, now the largest seed company in the world.

The Wallaces' coup de force became, for latter day apologists, "a combination [of theoretical advances of East, Shull, and Jones] that proved irresistible to even the most conservative agronomists!" This conservatism of agronomists is yet another myth of the hybrid-corn story. All the early attempts to breed hybrids for commercial production had ended up as failures. Jones' double-cross, for instance, performed miserably under Corn Belt conditions. After 15 years of work and a number of inflated claims from Shull and East, nothing of value had come of it, except for a single experiment. The theoretical explanation of hybrid vigor led to impractical breeding procedures. In the absence of government intervention, it simply had not made sense for breeders to bet their careers on such unconvincing evidence.

Economics of Hybrid Corn
Commercial hybrids decrease the yield of the following generation (see box). This means that farmers have to renew their seed every year. Hence, hybrids create a perpetual market for seed. Thus hybrid breeding opened up staggering profit opportunities. If a farmer stood to lose, say, 20 percent of his crop by the use of second generation seed from hybrid, and if his yield was 40 bu/acre, then his loss amounted to 8 bu/acre. At the time, a bushel of seed corn sowed 7 acres. Once a farmer had adopted hybrids (because public breeding work make them superior to non-selected open-pollinated corn), he would lose 56 bushels of grain by sowing a bushel of second generation seed from his own crop (instead of buying new hybrid seed). In theory then, a rational farmer should buy a bushel of hybrid commercial seed corn at any price less than 56 times the price of a bushel of corn for grain.

The price at which seed corn is sold could be entirely disconnected from its costs of production. The hybrid-seed corn industry in the United States and elsewhere had to establish a system of monopoly competition through sales effort, an important element of which was research and development of new varieties mainly out of public research work. Today, seed corn sells for $70 to $80 per bushel while the cost of production is about $15/bu. The difference between the two represents profits plus what the seed company spends to build barriers to entry: advertising, sales force, field tests, research and development to provide a steady flow of new varieties, etc. The rate of profit is staggering because very little capital is tied up in actual production, which is done by farmers working under contract.

Orthodox economists provided the final ideological touch to this fairy tale of science and technology. Zvi Griliches gained his early fame from two articles devoted to hybrid corn, one of which was considered a breakthrough in neo-classical economics since it showed for the first time that technological change could be amenable to economic analysis.

Griliches started with the assumption that "Hybrid corn, as everyone knows, increased corn yields." He then jumped into a mathematical economic treatment of data, a conspicuous feature of economics which reminds us of Aloibiades cutting off his dog's tail. When asked why he had done such a thing, the Greek statesman replied that the people, while pondering his dog's tail, would ignore important matters. The trick, albeit old, worked perfectly. No one saw that Griliches' 1957 paper was entirely tautological. For, if hybrids increase yields (everything else being equal), production increases, prices fall, and society benefits from the innovation! This is exactly the claim that the scientific community at large wanted "scientifically" established. "The overall social returns on publicly supported technological research have been very high"; they benefited everyone. "In the long run, no abnormal profits were made there," hence, state intervention was justified.

The real originality of Griliches' paper was in providing a figure that became a powerful ideological legitimation of the process of capitalist technological change. He computed a 700 percent yearly return for each dollar invested in hybrid-corn research.

This figure has ever since been a political weapon. The agricultural research establishment repeats it in support of its endeavors. In May 1984, two Assistant Professors at the University of California cited this figure in support of agricultural research in the Wall Street Journal. The article was part of the University's campaign to defuse a legal suit alleging that its research had served the rich and powerful rather than the consumer or the farm worker.

We suggest that a truly scientific endeavor would now be to compute the social costs of hybrid corn.