Comment

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AS BEFITTED someone investigating corn breeding, Henry A. Wallace was the product of good farm stock. Both his grandfather and father stood as participants in a tradition that applied science to agricultural practice. But Henry had something that neither of his illustrious ancestors had possessed. He had a prescience about him and that allowed Henry to get a jump on the field. In touch with the leading agricultural scientists of his day, Wallace very quickly determined how the scientists' science could be put into practice. Wallace was, in short, among the first to create an industrial technology of hybrid corn.

Although Wallace ought to be remembered for implementing and boosting hybrid corn, the way that his corn breeding career developed also is interesting and worthy of some comment. Indeed, Wallace was weaned on a very different set of notions than those that resulted in the marvelous hybrid corn revolution. When Wallace first examined the corn question, the views of scientists such as Iowa State's Perry Holden held sway. Like most other late nineteenth-century and very early twentieth-century corn scientists, Holden advocated selection of seed by inspection. Enthusiastically promoting that idea through corn shows, Holden called on farmers to compare and measure their corn according to an idealized standard. The standard took into account the plant's stand, the length of the ear, the size of the kernels, the type of dentition, and even such nebulous qualities as "cheerfulness." Only the most perfectly formed corn should be used for seed and Holden developed a complicated scorecard on which to rate the various factors. He even endorsed a system of judging, generally staffed by Iowa State's scientists. Farmers would bring their best specimens to a particular site; the judges would evaluate the contenders and finally announce the winners. Those declared victorious would have best approximated the idealized standard.[1] This process was kind of a midwestern beauty pageant where the corn was selected according to its form, though to my knowledge the contestants wore neither evening gowns nor sashes.

Implicit in this formulation, though, was the quite serious and commonsensible assumption proved thousands of times by farmers in their other endeavors, namely that like produces like. It suggested that selection of a particular ear of corn for seed according to certain visible characteristics would lead to the propagation and re-enforcement of those characteristics in the succeeding generations. And since form was equated with health and especially vigor, it was thought that the most outstanding specimens would bear progeny at least as vigorous: Seed taken from the most perfectly formed ears would yield the most corn.

And it was that sort of idea with which Wallace first broached the corn problem. Right from the start, he remained skeptical. In 1904, he put the Holden method to the test. He took thirty-three of the finest ears that he could find and planted them, the kernels of each corn constituting a single row. Then he measured the yield. To his amazement, he found that not only did the yield per row differ, but it did so dramatically.

1. For Holden, see, for example, P. G. Holden, "Selecting and Preparing Seed Corn," *Iowa Agricultural Experiment Station Bulletin #77* (Ames, 1904); and P. G. Holden, *The A, B, C of Corn* (Springfield, Ohio, 1906), *passim*. For other scientists, see, for instance, "Methods of Corn Breeding," *Illinois Agricultural Experiment Station Bulletin #82* (Champaign, 1902), 536; J. H. Wurst, "Corn Culture in North Dakota," *North Dakota Agricultural Experiment Station Bulletin #51* (Fargo, 1902), 100-02; and C. P. Hartley, "Improvement of Corn," *Memoirs of the Horticultural Society of New York* 1 (1902), 198-202. I would like to express my appreciation to Gregory A. Sanford, a graduate student in the Program of the History of Technology and Science, Department of History, Iowa State University, for his help in identifying some citations for the early portion of this paper.

Some rows produced a bountiful harvest while others stood virtually barren.[2]

Wallace did not stop there, however. In 1906, he lived in the same rooming house as M. L. Mosher, who was running for Holden the Story County version of the "Farmers' Variety Tests." These tests were authorized and funded by the state legislature and conducted by county, under the auspices of Iowa State's extension department. Interested county farmers were asked to select some seed and to give it to a member of the extension staff. He would use the county farm to test the yield of each farmer's seed. The purpose of this demonstration work was simple—to show farmers the importance of choosing their seed according to Holden's criteria. Mosher invited Wallace to help measure the yields of the Story County farmers' corn and Wallace once again came face to face with the incredible variation in the yielding power of corn seed.[3]

The extension of service proposed the tests primarily to demonstrate the value of Holden's selection method, but the result was quite different. In the seven years after 1906, the variety tests called into question the relationship between Holden's proclaimed physical corn characteristics and yield; the appearance of the best yielding corn did not fit neatly with his established criteria. Despite the anomolous situation, Holden did not abandon his approach. Instead, he modified it. He tampered with his scorecard, giving more credence to some factors and discounting others. For example, he concentrated his attention on the kernels at the center of the ear and ignored those on the butt and tip. In some cases, he also followed another path. He pinned the blame for the apparent dissonance between appearance and yield on corn show judges. He claimed that they often failed to adhere faithfully to his guidelines and, as a consequence, selected inferior corn, corn that did not conform to the appropriate idealized standard.[4]

2. The story is recounted in Paul DeKruif, *Hunger Fighters* (New York, 1928), 189-193.

3. Martin L. Mosher, *Early Iowa Corn Yield Tests and Related Later Programs* (Ames, 1962), 5, 16-22, and 29-42; Henry A. Wallace and William L. Brown, *Corn and Its Early Fathers* (Chicago, 1956), 100.

4. P.G. Holden, *Successful Corn Culture* (Des Moines, 1912), 19-21; and Mosher, 100-03. For other changes, see, for example, "Score Card For Dent Corn," *Ohio Agricultural Experiment Station Circular #61* (Columbus, 1906);

As Holden was pursuing this course, others in America investigated different lines. At about the time that Holden initiated Iowa's Farmers' Variety Tests, George Shull was completing a series of corn breeding or selfing experiments. Operating out of Cold Spring Harbor, Shull determined by inbreeding corn plants that common corn varieties were in fact a combination of a large number of strains. It was only through selfing for several generations that the constituent "pure" corn breeds revealed themselves. Though generally small and not very productive, these breeds would also breed true; that is, each time they were selfed, their progeny would bear a remarkable resemblance physically to each other and to their parents. Shull also carried the matter a step further. Several times he crossbred two dissimilar pureblood corn plants and found that when the cross nicked, the result would be extraordinary. The favorable cross would produce a plant larger and far more productive than its parents.[5]

While it would be incorrect to suggest that Shull's labors passed unnoticed, it would be accurate to say that they did not create a considerable stir. Aspects of his work proved particularly disturbing. First, the productivity or vigor exhibited in the first generation cross of two pure breeds quickly decreased when the crossed plant was selfed or pollinated by an identically crossed plant. It tended to approach the lack of vigor demonstrated by pure breeds. Second, the seeds of the first-generation cross were quite small, a reflection of the size of the parent plants. The smallness of the seeds led to the seedlings maturing later, a factor that made the crossed seeds more susceptible to inclement weather. Third, inbreeding itself seemed to violate nature's laws. Mother-son, father-daughter, and sister-brother unions always seemed to result in specimens of reduced size and

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A. T. Wianco, "Corn Improvement," *Indiana Agricultural Experiment Station Bulletin #110* (Bloomington, 1906), 109; Vernon Shoesmith, *The Study of Corn* (New York, 1910), 33-35; and M. L. Bowman, *Corn* (Waterloo, 1915), 402-415.

5. George H. Shull, "The Composition of a Field of Maize," *Proceedings of the American Breeders' Association* 4 (1908), 296-301; "A Pure Line Method of Corn Breeding," *Proceedings of the American Breeders' Association* 5 (1909), 51-59; "Hybridization Methods In Corn Breeding," *American Breeders' Magazine* 1 (1910), 98-107; and "The Genotype of Maize," *American Naturalist* 45 (1911), 234-52.

vigor. They appeared to perpetuate bad blood or to convert good blood into bad; inbreeding debilitated an organism. Only outbreeding led to vigor and the greater the diversity of good but different germ plasm the better.[6]

The apparent problems posed grave difficulties. They led some, such as Connecticut's Edward Murray East and Herbert K. Hayes, to downplay the commercial or practical possibilities of pure strain crosses and to stress varietal crosses.[7] In Iowa, Shull's revelation about the composite nature of corn took on another dimension. Its significance lay in the simple but important realization that the great number of purebloods in each corn variety made endless the possibilities of different combinations. Earlier investigators, such as Holden, had identified several varieties of corn by sight and then relied on the fitness of particular members of the variety—a fitness equated with form—to produce seed. In the wake of Shull's work, however, the notion of variety as a visible and constant or fixed manifestation of specific germ plasm and the corresponding emphasis on the fitness of particular members no longer held center stage. They were replaced by the concept of an almost infinite

6. The objections to self-fertilization had a long tradition. See, for example, Thomas A. Knight, "An Account of Some Experiments On the Fecundation of Vegetables," *Philosophical Transactions of the Royal Society of London* 89 (1799), 195-204; Charles Darwin, *The Effects of Cross and Self-Fertilization* (London, 1876), 233-40; G. E. Morrow and F. D. Gardner, "Field Experiments With Corn," *Illinois Agricultural Experiment Station Bulletin #25* (Champaign, 1893), 173-203 and *Illinois Agricultural Experiment Station Bulletin #31* (Champaign, 1894), 359-60; A. D. Shamel, "The Effects of Inbreeding in Plants," *Yearbook of the United States Department of Agriculture, 1905*, 377-92; E. G. Montgomery, "Experiments With Corn," *Nebraska Agricultural Experiment Station Bulletin #112* (Lincoln, 1909); and E. G. Montgomery, "Preliminary Report on the Effect of Close and Broad Breeding on Productiveness in Maize," *Twenty-Fifty Annual Report of the Nebraska Agricultural Experiment Station* (Lincoln, 1912), 181-192.

7. E. M. East, "The Relation of Certain Biological Principles to Plant Breeding," *Connecticut Agricultural Experiment Station Bulletin #158* (New Haven, 1907); E. M. East and H. K. Hayes, "Inheritance in Maize," *Connecticut Agricultural Experiment Station Bulletin #167* (New Haven, 1911); H. K. Hayes and E. M. East, "Improvement in Corn," *Connecticut Agricultural Experiment Station Bulletin #168* (New Haven, 1911); and H. K. Hayes, "Normal Self Fertilization in Corn," *Journal of the American Society of Agronomy* 10 (1918), 123-128. Also of interest is Lyman Carrier, "A Reason For the Contradictory Results in Corn Experiments," *Journal of the American Society of Agronomy* 11 (1919), 106-12.

number of purebloods which when combined in an almost infinite number of patterns gave the corn varieties their physical characteristics. But these varieties were indefinite; not all varieties contained germ plasm from the same purebloods. As a consequence, a variety was only something which demonstrated a similar appearance. It may well have had different properties, one of which could have been vigor.

Mosher was central to putting this new notion into practice. As Iowa's first county agent, he planned in 1912 the Clinton County Corn Yield Test. It was the first test in Iowa designed specifically to uncover a superior yielding strain or variety of corn adapted to the area. Working from a notion that all corn was in affect a series of complex hybrids, Mosher from 1913 to 1915 gathered seed corn from county farmers and planted it at some central point. Standardized climatically, every year he measured the yield of each farmer's seed and at the end of the period selected a strain of Reid's Yellow Dent as the most productive. He then labored to get all Clinton County farmers to adopt that strain. His efforts met with success. By the early 1920s, roughly 80 percent had switched.[8]

Wallace was not a prominent figure in the county yield test. As editor of *Wallaces' Farmer* and as a personal friend of Mosher's, he certainly knew of the Clinton County search. But Wallace was fascinated by the purebloods. In 1913, he began dismantling corn varieties into their constituent purebloods in his now famous basement. Over the course of the next several years he repeated much of Shull's work. Wallace's interest in corn purebloods came quite early. He started his examinations two years prior to Iowa State College's initial corn hybridizing experiments. While he clearly hoped for some agricultural application from his research, Wallace remained unable to solve the corn mysteries. Nevertheless, he kept his finger on the scientific community's pulse. Through the mail and in person, Wallace followed and participated in the scientists' corn deliberations. He also exchanged with them seeds of pure blooded specimens. And it was through Wallace's close contact with

8. Mosher, *Early Iowa Corn Yield Tests,* 61-70 and 73-74. Mosher then moved to Woodford County, Illinois where he conducted similar county yield tests. It was there that he found the famous Krug corn. See Ibid., 75-89.

corn scientists, particularly the Connecticut Agricultural Experiment Station's Donald F. Jones, that he learned of a method to translate his observations into practice.[9]

In the years 1918 to 1920, Jones not only announced a mechanism that made hybrid corn practical but also explained the subject in a way to stimulate further developments. The mechanism was the double cross and it entailed four pureblood lines and two generations. It not only yielded larger seeds, a factor that boosted the seedlings' resistance to bad spring weather, but it also increased dramatically the number of seeds, an occurrence that made the high yielding hybrid corn commercially feasible.[10] But Jones's understanding of the phenomenon of hybridization rested as the key to his work. Standing on the shoulders of Thomas H. Morgan and others, Jones recognized that the hereditary factors in corn were carried in generally indivisible groups.[11] That virtually precluded the possibility of getting all the more favorable characteristics together in one individual. Traits were linked and breeding for a desirable trait most likely would also expose undesirable traits. Thus Jones explained the dwarfishness and lack of vigor of most inbred corn.

In Jones's conception, however, inbreeding was imperative. Only by inbreeding could investigators reveal the root stock, the good and bad traits, traits that were linked. But crossing offered a method to rid plants of their inferior traits. Starting from the assumption that "favorable growth characters tend to be expressed rather than unfavorable ones, whenever the two are paired," he advocated crossing because "it brings together the greatest number of different factors." Presumably, the in-

9. DeKruif, *Hunger Fighters*, 226-28; and Roy Olin Westley, "A Study of Corn Hybridization," (M.S. thesis, Iowa State University, 1917), 10-25.

10. D. F. Jones, "The Effects of Inbreeding and Crossbreeding Upon Development," *Connecticut Agricultural Experiment Station Bulletin #207* (New Haven, 1918); D. F. Jones, "Segregation of Susceptibility to Parasitism in Maize," *American Journal of Botany* 5 (1918), 295-300; E. M. East and D. F. Jones, *Inbreeding and Outbreeding: Their Genetical and Sociological Significance*, (Philadelphia, 1919); and D. F. Jones, "Selection in Self-Fertilized Lines as the Basis For Corn Improvement," *Journal of the American Society of Agronomy* 12 (1920), 77-100.

11. For Jones's precursors, see, for example, T. H. Morgan, A. H. Sturtevant, H. J. Muller, and C. B. Bridges, *The Mechanism of Mendelian Heredity*, (New York, 1915); and R. C. Punnett and P. G. Bailey, "On Inheritance of Weight in Poultry," *Journal of Genetics* 4 (1914), 23-39.

ferior traits would be suppressed or dominated by favorable ones. And through use of the double cross and four different blood lines—each selected with a certain purpose in mind—researchers would be able to create types of corn that not only yielded very well but were also adaptable to an extraordinary variety of climatic conditions and resistant to many common corn pests and diseases. They sacrificed only the structural similarity of the single cross.[12]

Jones, then, opened the way to a productive multipurpose corn. It took some time for farmers to grasp the significance of his work, however, As Jones was publicizing his views, the Iowa Corn and Small Grain Growers' Association was calling for an Iowa Corn Yield Test. Similar to the county test initiated by Mosher, the Iowa test divided the state into several districts and sought to select the best yielding corn in each. The trials began in 1920; Wallace did not enter until 1922. It was at that time that he may well have produced his first hybrid. Test officials identified Wallace's seeds in that year as "unknown." In any case, his seeds did not yield well and he finished in the middle of the pack. He sat out the test in 1923, the year in which hybrids were generally acknowledged first to have appeared in the contest, but joined the test the next year. This time he offered two types of seeds, a single cross of Leaming and White Pearl and a single cross of Bloody Butcher and White Pearl. Both ranked near the top. In 1925, Wallace produced several double crosses for the trials, each of which did exceptionally well.[13]

In 1926, the success of the hybrids, particularly Wallace's hybrids, caused the growers to divide the test into two classes, one restricted to hybrids, the other for open pollinated varieties. During the next few years, Wallace's corn consistently placed high in the hybrid category and swamped the other group.[14]

12. Jones, "Selection In Self-Fertilized Lines," 81 and 86-95.

13. Mosher, *Early Iowa Corn Yield Tests,* 90-94; Iowa Corn and Small Grain Growers' Association, *Corn Yield Contest 1920* (circular); Iowa Corn and Small Grain Growers' Association, *Iowa Corn Yield Test—Results of 1922 Tests, Plans for 1923 Tests* (circular), 5; Iowa Corn and Small Grain Growers' Association, *Iowa Corn Yield Test—Results of 1924 Tests, Plans for 1925 Tests* (circular), 3-4; and Joe L. Robinson and A. A. Bryan, *Iowa Corn Yield Test—Results of 1925 Tests, Plans for 1926 Tests* (circular), 5-10.

14. Robinson and Bryan, *Iowa Corn Yield Test—Results of 1925, Plans for 1926,* 11-13; Joe L. Robinson and A. A. Bryan, *Iowa Corn Yield*

Wallace and other corn breeders remained interested in the open-pollinated results, but for a new reason. It now seemed likely that a high yielding open-pollinated variety contained one or more pure bloods of outstanding quality. Hybridizers needed only to inbreed the variety to disclose the pure bloods and then to double cross the high yielding pureblood with other suitable purebloods.[15]

Despite Wallace's infatuation and good fortune with hybrid corn and while he manufactured seed, he warned farmers to be careful. As late as 1937 in the fourth edition of his classic *Corn and Corn Growing*, he advised that "if further experiments continue to prove that crossed inbreds have such an advantage over open pollinated corn, it will pay to go to considerable pains to produce such seeds." If hybrids continue to bear up, reported Wallace, "the problem then will be to get these inbreds into the hands of reliable, well-trained people experienced in producing seed corn, who can be relied upon to do a good job of crossing the inbreds so that farmers who buy will know just what they are getting."[16]

Clearly, Wallace's dalliance with hybridization did not end in 1933 with his appointment as secretary of agriculture. In particular, two events stand out. In 1936-37, the USDA devoted its yearbooks—nearly three thousand pages—to a discussion of the practical agricultural implications of the newest work in genetics.[17] Though the genetics of corn captured only a small portion of these volumes, Wallace's longstanding exposure to what by then had become corn genetics certainly sensitized him to the utility of genetics research and probably contributed to the decision to publish the two collections of essays. The second occurrence is harder to pin down. In fact, it may not have even

Test—Results of 1926 Tests (circular), 3, 7-15; and H. D. Hughes, Joe L. Robinson, and A. A. Bryan, "High Yielding Strains and Varieties of Corn for Iowa," *Iowa Agricultural Experiment Station Bulletin #265* (Ames, 1929). The bulletin summed up the results of the first eight years of the tests. For a popular summary of the tests and the early years of Wallace's Hi-bred Seed Company, see De Kruif, *Hunger Fighters*, 228-32.

15. Mosher, *Early Iowa Corn Yield Tests*, 96.

16. Henry A. Wallace and Earl N. Bressman, *Corn and Corn Growing*, 4th ed. (New York, 1937), 229.

17. United States Department of Agriculture, *Yearbook of Agriculture, 1936 and 1937* (Washington, 1936 and 1937).

happened. In addition to his corn work—or maybe because of it—Wallace also displayed a strong interest in statistics. He even co-authored a statistics manual in 1925 for use at Iowa State.[18] The story goes that in the late 1930s or early 1940s, Wallace learned of a machine invented at Iowa State by a physicist, John V. Atanasoff. Atanasoff had created a device capable of performing mathematical calculations at high speed. Supposedly, Wallace contacted him and asked if the machine could be made to perform statistical calculations that would replicate some aspects of corn breeding; it would make some field work unnecessary and, as a consequence, provide a swifter means of selecting superior and nicking blood lines.[19] Atanasoff's machine was the world's first electronic digital computer. Whether the story was true or not, it nonetheless serves to point out Wallace's ability to grasp the heart of the matter and to apply it to practice. And it was that quality that made Wallace an early and leading figure in hybrid corn.

18. Henry A. Wallace and George W. Snedecor, *Correlation and Machine Calculation*, (Ames, 1925).

19. I have not as yet been able to document this story in either the Atanasoff or Wallace papers.