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Agricultural Innovators and Innovations

DONALD F. JONES AND HYBRID CORN

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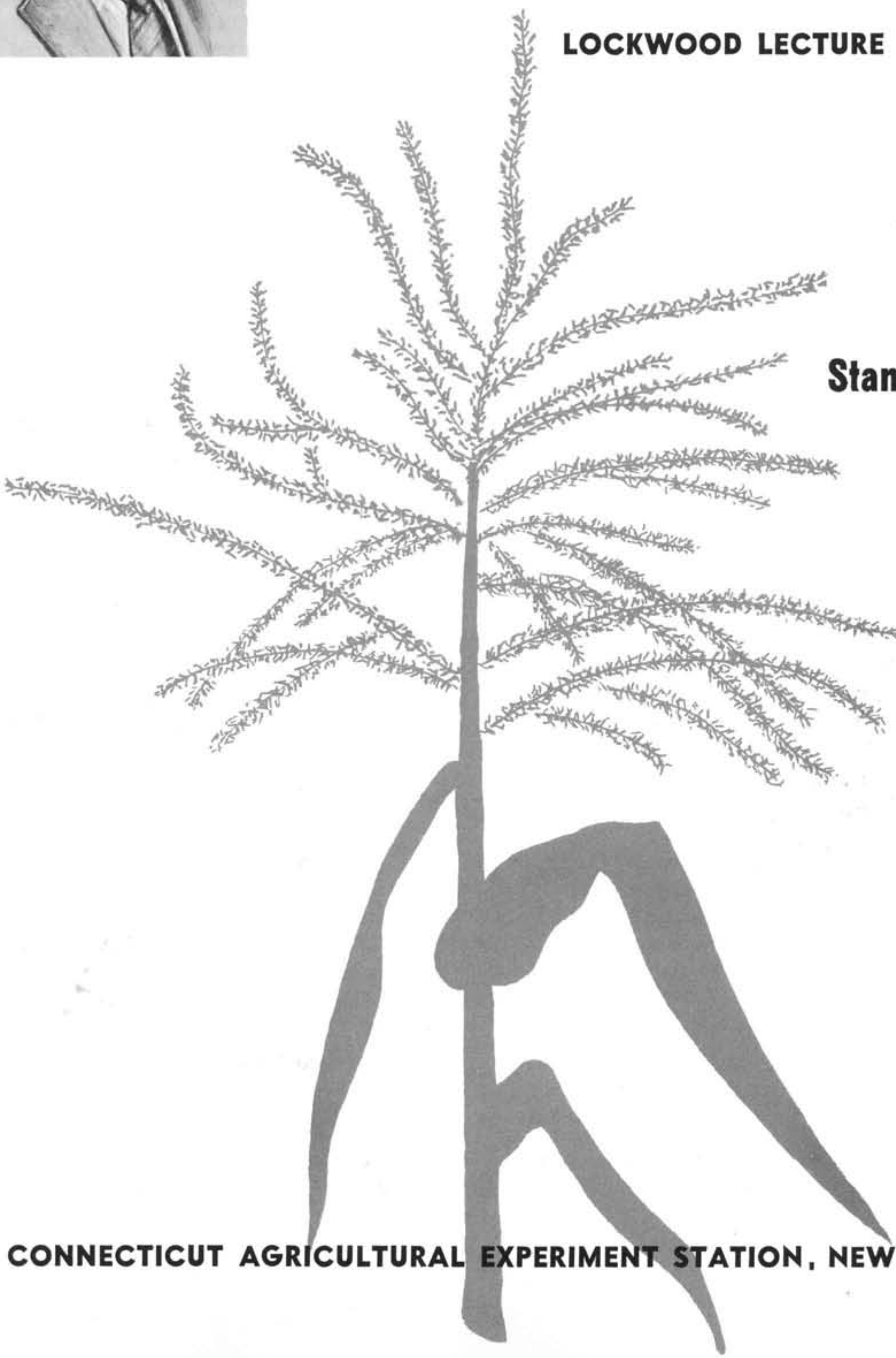

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FOREWORD

The "Green Revolution" is a term that has come into prominence in the mid-Twentieth Century to describe a rapid and marked increase in world production of cereal grains, notably wheat, rice and corn. Like all such simplistic terms, however, the "Green Revolution" conceals more than it reveals, for the truth is that this "revolution", like the cereal plants it is concerned with, has roots extending far into the past.

Many civilizations have sought ways to produce more grain from crops simply to increase basic food supplies. But it was not until the late Nineteenth Century that scientific understanding of the growth and reproduction of plants was incorporated into practical farming on a rational and large-scale basis. Properties of soils, effects of climate and the nutrient requirements of crop plants, combined with a basic knowledge of plant genetics, have been essential precursors to the "Green Revolution".

Perhaps no plant can better symbolize the effects of this revolution than the one known as maize or corn.

And perhaps no individual can better epitomize the kind of thinking necessary to bring about such a revolution than Donald F. Jones, plant breeder and geneticist at The Connecticut Agricultural Experiment Station for 45 years. His work with hybrid corn is an outstanding illustration of science made practical.

Long before "Green Revolution" became a household word, hybrid corn had become a household item. Corn is truly the king of cereal crops in the United States and, on a larger scale, the annual world production of corn is exceeded only by that of wheat and rice.[16c]

The large number of varieties or races of corn (probably between 100 and 150) has long been recognized. Its origin in the western hemisphere is a virtual certainty. That it has been cultivated for thousands of years is beyond dispute. The fact that it grows between approximately 45° S latitude and 60° N latitude and at elevations ranging from sea level to more than 12,000 feet is, by itself, an indication of the adaptability of corn and its domesticators.

Consider, also, that corn plants may be from two feet to 20 feet in height and may require as few as 60 days or as much as 11 months to attain maturity.

Although the number of ears on a single corn stalk may vary from one to six, the single ear overwhelmingly predominates in American corn fields. There is an almost mystical rule that the number of rows of seed on a single ear of corn is always an even number, from 4 to 36 and the length of an ear varies from less than one inch to about two feet.

In the United States nearly all the corn grown is hybrid; the crop yielded nearly six billion bushels of grain in 1975.[1]

The story to be related here is an unfinished one, for it can neither be a complete history of hybrid corn nor a biography of Donald F. Jones. It is, rather, a story of Donald Jones isolated temporarily from the larger context of that peculiar Twentieth Century phenomenon known as hybrid corn. In the same manner as an artist focusing upon one corner of a painting or a scientist devoting his energies to the study of a single enzyme, so I have attempted to highlight those aspects of Donald Jones' career that seem most relevant and intriguing with respect to agricultural innovations, especially as they are related to hybrid corn.

Those of us who seek to understand our past are only too painfully aware that history is an artifact, a creation of mankind. Nevertheless, an understanding of history, even when incomplete or imperfect, is necessary to determine the pathways we must travel in the future.

Donald Jones perceived this idea when he looked back upon the attempts to improve agricultural production and then set about the task of converting those attempts into reality.

Agricultural Innovators and Innovations

DONALD F. JONES AND HYBRID CORN

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On January 20, 1976, the National Portrait Gallery, a bureau of the Smithsonian Institution, placed on exhibit a bronze bust of Henry A. Wallace, former Secretary of Agriculture and Vice President of the United States. A news release announcing the exhibit says about Wallace:

> His studies at Iowa State College, where he majored in agriculture, prepared him for his work in the field, where he developed hybrid corn and conducted research that for over two decades remained among the four or five most important contributions in plant genetics.[2]

This tribute to his role in the commercial development of hybrid corn, leaves one with the erroneous impression that Wallace did most of the development himself. A study of numerous accounts of the emergence of hybrid corn, however, shows that more than one candidate has been acclaimed as its founder or father: W.J. Beal, C. Darwin, C.G. Hopkins, E.M. East, G.H. Shull, J.R. Holbert, E.D. Funk, H.A. Wallace, and of course, Donald Jones.

In point of fact, this kind of historical search is a rather useless and thankless task. I shall dispense with it posthaste by emphasizing that hybrid corn is not the product of any single person's activities: Nature and the American Indians were hybridizing corn long before any of the aforementioned people were born.

Well, then, what are we talking about when we say that hybrid corn has been one of the major contributions of modern plant breeding? Inasmuch as the principal emphasis of this paper is being placed upon Donald Jones, I'll let him answer my question:

> The function of hybridization is the rearrangement of already existing characters, the bringing together of qualities scattered about in different forms into one or a few individuals which represent the beginning of a variety, or a new breed.[3]

Hybrid corn is thus the product of a deliberate and specific process by which the plant breeder manipulates existing characters to produce a new variety. The plant breeder selects from those varieties he has produced and continues their propagation. The procedure is founded upon the science of genetics and the art of recognizing a good thing when you find it. And, in both these qualities, Donald F. Jones was an acknowledged master.

Jones did not invent hybrid corn, but he did devise a method for producing hybrid corn of remarkable uniformity which yielded, on the average, more grain per acre than any existing variety of open-pollinated corn.[4] This method is illustrated in Fig. 1. A selected variety of corn (A) is inbred for at least five generations, then crossed or hybridized with a different selected inbred (B). The resultant hybrid (A x B) is grown and crossed with another corn plant produced by the same method but using two other inbreds (C x D). Seed of this four-way or double-cross then becomes the article of commercial trade, sold to farmers for the raising of crops primarily to feed pigs, poultry and cattle.

A traditional history of hybrid corn such as A. Richard Crabb's, *The Hybrid Corn Makers: Prophets of Plenty*,[5] does an excellent job in detailing the consequences of Jones' now famous double-cross. A more recent study, Paul C. Mangelsdorf's biography of Donald F. Jones, points out that Jones was not the first to develop the double-cross—George Shull did so in 1910/11, about 6 or 7 years before Jones.[6]

Again, some historians claim that Shull didn't realize the practical importance of the double-cross. Others state that he realized its commercial possibilities but lacked interest to follow it up.

Whatever the explanations may be for George Shull, the success of Donald Jones in both making the double-cross and in following it up with a concerted effort to "sell" it to farmers, seed producers, and his fellow geneticists, is the real beginning of the story of Donald F. Jones and hybrid corn.

Consider, if you will, a not-quite 25-year-old man, only a few years out of his native Kansas, arriving at The Connecticut Agricultural Experiment Station to take over the duties of plant breeder. He is, like many a youngster, certain that the work assigned to him will not lead anywhere. He knows about Shull's work with corn inbreds from his undergraduate days. He knows that weak, poor-yielding inbred corn plants, when cross-fertilized, produce vigorous, high-yielding plants. He also knows that the cost of producing these hybrids is prohibitive because the inbreds produce relatively little seed. He follows what appears to be the next logical step by crossing two of these first generation single crosses and obtains a beautiful progeny and an elegant solution to the production problem: double-crossed corn.

Donald Jones actively campaigned for adoption of this technique by commercial seed producers until the late 1920s. He recognized that the average farmer could not carry out the extensive inbreeding, much less the selection and crossing necessary to produce a high-quality final product. In 1919 he commented:

> . . . it is something that may 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. The man who originates devices to open our boxes of shoe polish or autograph our camera negatives, is able to patent his products and gain the full reward for his inventiveness. The man who originates a new plant which may be of incalculable benefit to the whole country gets nothing—not even fame—for his pains, and the plants can be propagated by anyone. There is correspondingly less incentive for the production of improved types. The utilization of first generation hybrids enables the originator to keep the parental types and give out only the crossed seeds, which are less valuable for continued propagation.[7]

Jones, with slight variations, hammered out this theme again and again: The *practical* value of inbreeding to obtain plants possessed of desirable qualities while dispossessed of undesirable ones. The *practical* value of crossing so as to introduce hybrid vigor into the resultant progeny. The *practical* value of a second or double-cross to avoid undue expense in seed production.

This message was carried in his 1919 book with E.M. East, called *Inbreeding and Outbreeding*. But, in whole or in part, the same message appeared in the popular magazine, *Wallace's Farmer*,[8] as well as in the *Breeder's Gazette*[9] and *Scientific American*.[10] In 1920, Jones communicated his ideas through the *Journal of the American Society of Agronomy*[11] in an article which, historically, represents both a summation of what had been accomplished and a prediction of what was to come. Here, Jones repeats his contention that selective inbreeding is a positive virtue; that the crossing of selected inbreds is the way to obtain corn plants with predictable yields, with known disease resistance, but without extreme variability. In laymen's terms: you would know *before* you planted the seed just what kind of crop you were going to get (weather, soil, fertilizers, etc., permitting).

In terms of the future of hybrid corn, Jones postulates that it is theoretically possible to obtain a single plant possessed of nothing but desirable characteristics without the necessity of crossing at all!

> Theoretically, if all the factors contributed by the parental strains to make the hybrid valuable could be gathered together in one plant, that plant would be the homozygous progenitor of a variety of corn which would be as stable as any natural self-fertilized species, such as wheat. . . . In fact, for the first time there would be a true variety of corn. So-called varieties of corn at the present time are merely germinal hodge-podges. . . . Investigational work along this line has great opportunities.[12]

Well, what does one expect of the young if not grandiose ideas? Donald Jones, however, recognized the problems involved in such an undertaking when he stated:

> . . . let us not deceive ourselves as to the magnitude of the task ahead . . . no one can estimate the number of factor differences in corn concerned with growth vigor.[13]

After calculating the known hereditary factors and their possible combinations, Jones concluded that to have one chance of finding the ideal plant, corn

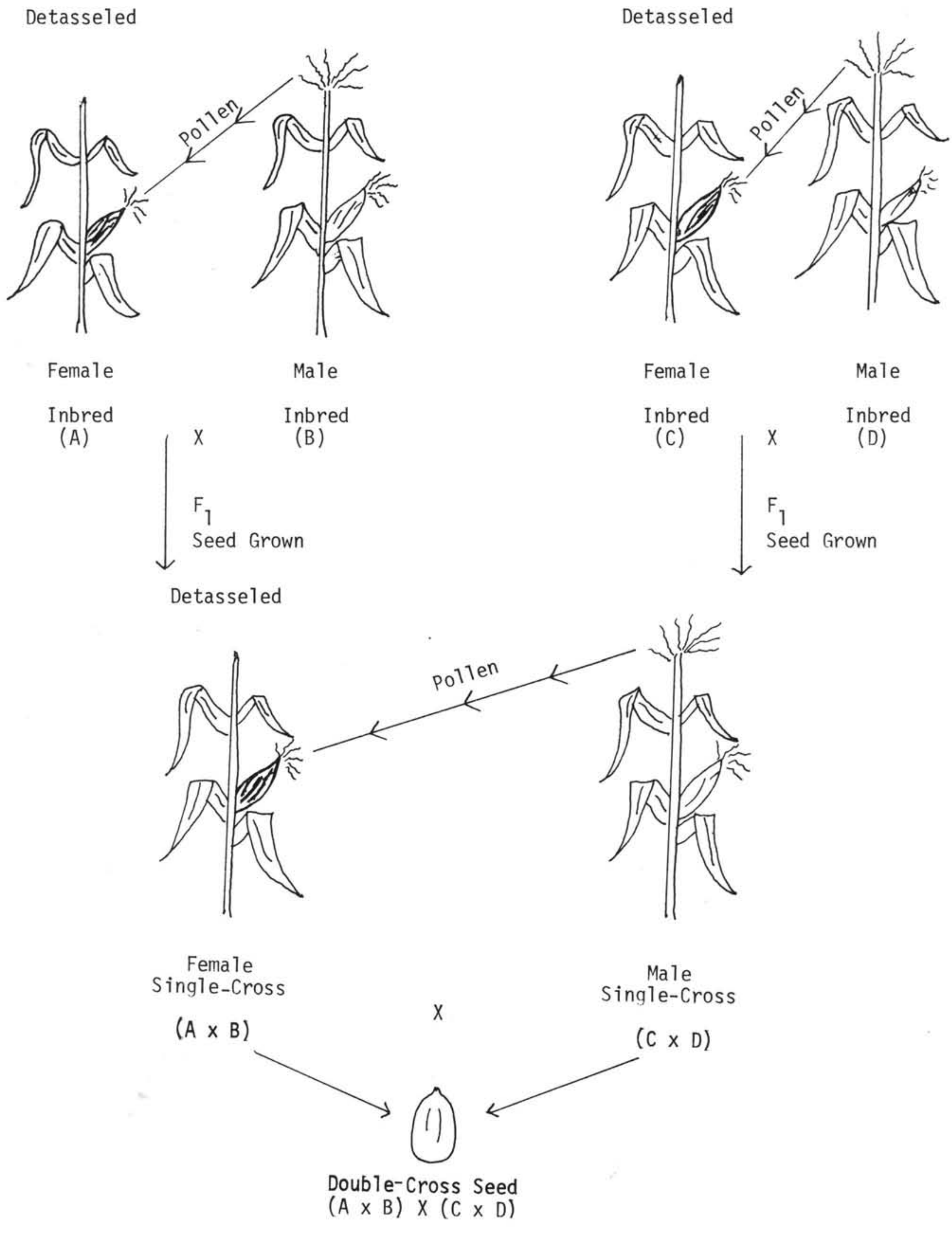

Fig. 1. Production of double-cross hybrid corn seed, 1917.

would have to be grown on nearly 4 trillion times the area of the United States. And then, somewhat plaintively, he asks: "Even if it were possible to grow this number, how could this one plant be identified so as to be protected from cross-pollination?"[14]

On a more realistic and practical note, he comments that the double-cross is no more than a stopgap measure, to be used only until sufficiently good inbreds are obtained to make the single-cross commercially feasible.[15] Figure 1 illustrates one of the reasons for working toward this goal. The double-cross requires two detasseling operations, the single-cross only one. Any procedure that would reduce or eliminate this expensive manual-operation would be welcome, to say the least.

The 1920s witnessed the emergence of Donald F. Jones as a protagonist of hybrid corn, or as he so often called it, crossed corn. Many of his publications were directed toward awakening the American agriculturalists to the advantages of hybrid corn. Visits to the Corn Belt allowed him to convey his beliefs to farmers, experiment station personnel, and seed producers. Attendance at professional meetings provided him with forums to discuss hybrid corn. Even his textbook, *Genetics in Plant and Animal Improvement,* published in 1925, contains an extensive discourse on the positive aspects of hybridization.

Then, from the late 1920s to the mid-1940s, his publications on the subject dropped effectively to zero. True, there were cooperative papers, principally with W. Ralph Singleton, dealing with hybrid sweet corn; but, in fact, there was little new material to offer. This does not imply that Jones had quit working on the problem. On the contrary, his notebooks and other records indicate that he continued the study of inbreds and the development of new hybrids. What is clear, however, is the "grand idea" had become reality. Other geneticists, plant breeders at experiment stations as well as the USDA, and seed producers were, in ever-increasing numbers, investigating the potential of hybrid corn. Statistics illustrate this vividly. In 1933, approximately 100,000 acres of land were planted to hybrid corn. In 1939, the acreage was 20,000,000—more than 20% of the corn producing land in the United States. By the mid-1940s, the figure had risen to over 60%.[16a, 16b]

Donald Jones had made his point. Having done so, he turned to what might be described as pure genetics by focusing his attention on hereditary aspects of the corn plant and atypical growth, a subject closely related to cancer and tumors. I submit that these endeavors, in addition to his work on practical corn breeding, formed the rationale for his admission into the prestigious National Academy of Sciences in 1939.

By 1940, Jones' reputation as a geneticist and corn breeder was well established. What more could one expect of a man who had devoted 25 years to the development and application of a revolutionary change in agricultural practices? As a matter of record, Donald Jones was deeply immersed in two other programs that added significantly to his career accomplishments. The first was concerned with the improvement of other cultivated plants; the second was destined to bring about a new revolution in the hybrid seed corn industry.

In 1931, Jones commented:

> History has much to say about generals and battles. Its pages are filled with the deeds of emperors and kings, too seldom glorious. But the major factor in the growth of states and empires has been the origin and development of domesticated animals and cultivated plants.[17]

He follows with a description of a banquet in Sir Walter Scott's novel, *Ivanhoe,* a scene which depicts a meal without potatoes, turkey, cranberry sauce, pumpkin pie, coffee and cigars.

> Peas and cabbages were there, but no knight in armour ever ate a tomato salad. Queen Guinevere never tasted corn on the cob.[18]

Jones was, of course, paying tribute to those plants and animals contributed by the New World to the Old. As chairman of the Department of Plant Breeding (later, Genetics) at The Connecticut Agricultural Experiment Station, Jones directed programs aimed at the improvement and development of a large number of edible plants such as squashes, cucumbers, tomatoes, peppers and strawberries. But he was not content merely to oversee research.

Jones carried the message directly to the people of Connecticut through frequent talks at garden clubs, farmers' meetings and the like. During World War II he was a consultant on establishment and maintenance of Victory Gardens. He often appeared on radio to convey to a larger audience the basic principles of successful gardening.

In the early 1940s he became a regular contributor and later an editor of the popular magazine, the *Rural New Yorker,* a position he maintained until the mid 1950s. As an editor he replied to questions about gardening and horticulture. It was not unusual for Jones to answer as many as 400 letters a year, on topics ranging from methods of planting seeds to the most efficient ways of handling manure piles. It is a measure of this man's dedication that he answered each request personally. There were no stock or format responses to be mailed out by a secretary. In addition, he wrote from one to thirteen articles annually, demonstrating a wealth of knowledge about cultivation practices, fertilizers, pest control, soils and vegetable storage, to name but a few.

As a contributor to other popular magazines, Donald Jones demonstrated a characteristic seen much earlier; his desire to make scientific agriculture available to laymen as well as scientists. And, while this practice was not confined to Donald Jones, I believe he did far more than the average in this respect. As a rhetorical question, one might ask: who, amongst the workers in any field of research would, in addition to his professional duties, take on the task of routinely keeping the public informed of the significant aspects of such research?

To understand fully Jones' contribution to a second revolutionary development in hybrid corn, it is necessary to turn back the clock to 1920 and take another look at the procedures involved in producing hybrids. As Fig. 1 illustrates, a critical feature is the necessity of detasseling plants that are to serve as the female or seed parent. No small wonder that Jones first concentrated upon the positive values of hybrid corn, for once the seedsmen recognized the scientific, technological and financial benefits to be obtained from hybrid corn, they would be willing to put up with the laborious task of detasseling. Then, and only then, would Jones have breathing room to consider ways to avoid or eliminate the problem. In his own quaint way he said:

> When, therefore, a method which is both commercially remunerative and scientifically exact is available, are the agronomists of this country going to be slow in applying it?[19]

I think it safe to assume that the then 30-year-old Jones knew what he was talking about. And, although another 15 years were required before hybrid corn began to replace open-pollinated varieties on a large scale, his understanding of what the "agronomists" reaction would be, was in modern terms, on target.

Between 1920 and 1944, Donald Jones maintained an almost continual search for a method to avoid detasseling. Chemical treatments, physical separation procedures, heat exposure and special hybrids were some of the means tried. All were unsuccessful.

The beginning of what turned out to be the solution is in a 1930 paper by Singleton and Jones:

> In 1923 several progenies of white flint corn from various sources were being selfed [inbred] the second time. One of these progenies was found to be segregating for a factor causing the tassel to be sterile. This factor has been named "male sterile". . . .[20]

The authors commented further that this factor:

> has some commercial possibilities in the production of crossed seed corn. . . . Detasseling a large field is not only costly but tedious . . . possibly a considerable saving in the cost of production of crossed seed can be effected by the use of the male sterile factor.[21]

On paper, the idea looked workable. Incorporating a male sterile factor would avoid the necessity of detasseling. Unfortunately, the method was never put into practice because Jones never reported success. Nevertheless, as late as 1941, he considered it feasible as he stated:

> By the use of a linked, sterile tassel gene, it is possible to produce crossed seed without detasseling.[22]

In early March 1944, Donald Jones met with Paul Mangelsdorf, a former colleague at The Connecticut Agricultural Experiment Station and at the time Professor of Botany at Harvard. During the conversation, Jones remarked that if he only had a good source of male sterile corn, the detasseling headache would be greatly relieved. Mangelsdorf replied that such a source was available; that he had discovered a cytoplasmic male sterile plant at the Texas Agricultural Experiment Station in 1938. Mangelsdorf was not successful in using it to avoid detasseling, so he had dropped the subject.[23]

Now we have an interesting situation. The male sterility that Jones had been studying was transmitted from one generation to the next via the chromosomes. The male sterility isolated by Mangelsdorf was carried by the cytoplasm—the non-chromosomal part of the female seed outside the nucleus.

Cytoplasmic male sterility had been discovered in a number of plants including flax and onion and, in 1931, Marcus Rhoades had announced the isolation of corn plants exhibiting cytoplasmic male sterility, or cms, as it is often abbreviated.[24] By 1944, cms had been incorporated into the production of hybrid onion seed by Henry Jones of the USDA,[25] but no one had found a method to do the same with cms in corn.

Examined from a slightly different but most valuable perspective—hindsight—records indicate that a number of individuals either suggested or attempted to use cms to avoid detasseling. But, like Donald Jones, they met with no success, usually because the male sterile female plants when crossed with plants yielding viable pollen, produced only partial sterility in the progeny. In the language of the day, the cms condition was unstable. No producer was going to use a method which did not guarantee 100% control over the parentage and offspring of his hybrid corn seed.

As far as Donald Jones is concerned, we have a mystery on our hands. Why did he not understand and use cms almost immediately? He was, after all, alert to the possibilities of male sterility in corn. In the simplest terms, there is no extant record which shows that he even knew about cms in corn prior to 1944! Donald Jones was usually on top of the literature in his field. He wrote papers in the late 1930s and early 1940s that cite other works of Marcus Rhoades. It is most difficult to believe that he was unaware of Rhoades' discovery in 1931. One bit of evidence can substantiate this belief indirectly. The Proceedings of the Sixth International Genetics Congress (held at

Ithaca, New York in 1932) edited by Donald Jones, lists a number of exhibits illustrating aspects of maize genetics. Exhibit #9 from The Connecticut Agricultural Station is described as: "Linkage of Endosperm Color and Male Sterility." Exhibit #10 is characterized as: "Cytoplasmic Male Sterility," some of the corn plants being supplied by the Agricultural Experiment Station at Cornell where Marcus Rhoades was working in the Department of Plant Breeding! No, I suspect that he probably did know of cms but that three factors contributed to his neglect of cms as a solution to the detasseling problem.

First, Jones had his own brand of male sterility in corn to work with. In the mid-1930s, cms was no more than a recognized fact. Its causation was (and still is to a large extent) inexplicable. Genetic male sterility was at least partially explainable in Mendelian or hereditary terms and, outwardly, subject to specific control.

Secondly, and I believe more importantly, during this time the hybrid seed corn industry was still a fledgling. There was no immediate need for a solution to a still hypothetical, large-scale problem. Remember, Donald Jones, was, above all, a pragmatic scientist. He operated best in situations that called for practical solutions to practical problems. And, he was no longer the exuberant youth of 1920 with a single "grand idea". He was now a mature geneticist and plant breeder with other interests competing for his time.

Finally, the mid-1930s was a period of desolation and depression in the farm areas of the U.S. Overproduction rather than insufficient crop yields had a major impact on national farm policies. Incentives for increased efficiency certainly existed, but, psychologically, increased efficiency had long since come to imply increased production, and increased production was definitely not desirable.

By 1944, all this had changed. World War II thrust a tremendous burden upon the agricultural capacities of the United States. As far as corn was concerned, hybrid seed offered the way to increased yields. And hybrid seed corn had to be detasseled—a laborious, tedious, expensive operation.

The Jones/Mangelsdorf meeting of March 1944, bore interesting fruit with respect to this operation, for Mangelsdorf wrote almost immediately to his former colleague, John S. Rogers, at the Texas Agricultural Experiment Station:

> Sometime ago I was telling Dr. D.F. Jones of the Connecticut Agricultural Experiment Station about finding a dominant male sterile (probably cytoplasmic) . . . and how I had the bright idea of transferring this characteristic to an inbred strain by repeated backcrossings. The F_1 single cross would be completely pollen sterile and detasseling to produce a double cross would be eliminated. I also told him how it finally dawned upon me that the crop grown by the farmer would also be pollen sterile and hence would produce no seed. He pointed out that the method might still be useful; that the hybrid seed producer could produce, say, three fourths of his seed by this method and mix it with one fourth produced by ordinary methods, thus saving three fourths of the labor of detasseling and yet providing that one plant in every four in the farmer's field is fertile.
>
> I think his idea is sound. In any case, he would like to have seed of this male sterile. . . . See if you can find any of this material and if so, send Dr. Jones some seed of it.[26]

Out of such a small beginning was a great development to emerge.

The seed was not available until 1945, but in the meantime Jones obtained some other cms corn from Merle Jenkins of the USDA so that the first experimental plantings were made in the spring of 1944.

Working continuously in a manner reminiscent of his earliest days at the Station, Jones developed the appropriate inbred strains. He received the Texas cms seed in 1945, and by 1946 had obtained additional stock from Brazil. In 1948 he had a sufficient number of cms inbreds and single crosses available for field testing. Over the years he sent a great deal of these materials to seed producers for large-scale experimental purposes. Sending experimental seed to growers in Florida and Mexico provided an additional crop each year.

In time, Donald Jones' hope became a reality. True, elimination of all detasseling had not been achieved, but one-half to three-fourths was no longer necessary. Even the portion that remained was not far from extinction because Donald Jones had one more discovery up his sleeve.

In the early days of experimenting with cms, he had observed that it was often difficult to induce sterility in some of the inbreds. Careful analysis led him to believe that some factor either prevented cms from being expressed or caused the sterility factor to disappear, thus rendering the next generation fertile. Jones ultimately concluded that cms plants could be crossed with pollen that carried a fertility-restoring gene. While the sterility factor itself was cytoplasmic and was carried by the seed parent, its effect could be negated by using a pollinator carrying a dominant gene for fertility. What this meant to seed producers was elegantly simple: no more detasseling.

Figure 2 represents the procedure for producing hybrid seed corn without detasseling as it appeared in 1956. Inbred (A), male sterile is crossed with a normal inbred (B), the resultant single-cross (A x B) being male sterile. Inbred (C), male sterile, when crossed with inbred (D) containing a pollen-restoring gene yields a restored fertile single cross (C x D). The two single-crosses are then hybridized so that the final double-cross possesses the fertility-restoring gene. This cross, (A x B) x (C x D), produces a normal crop of hybrid corn.

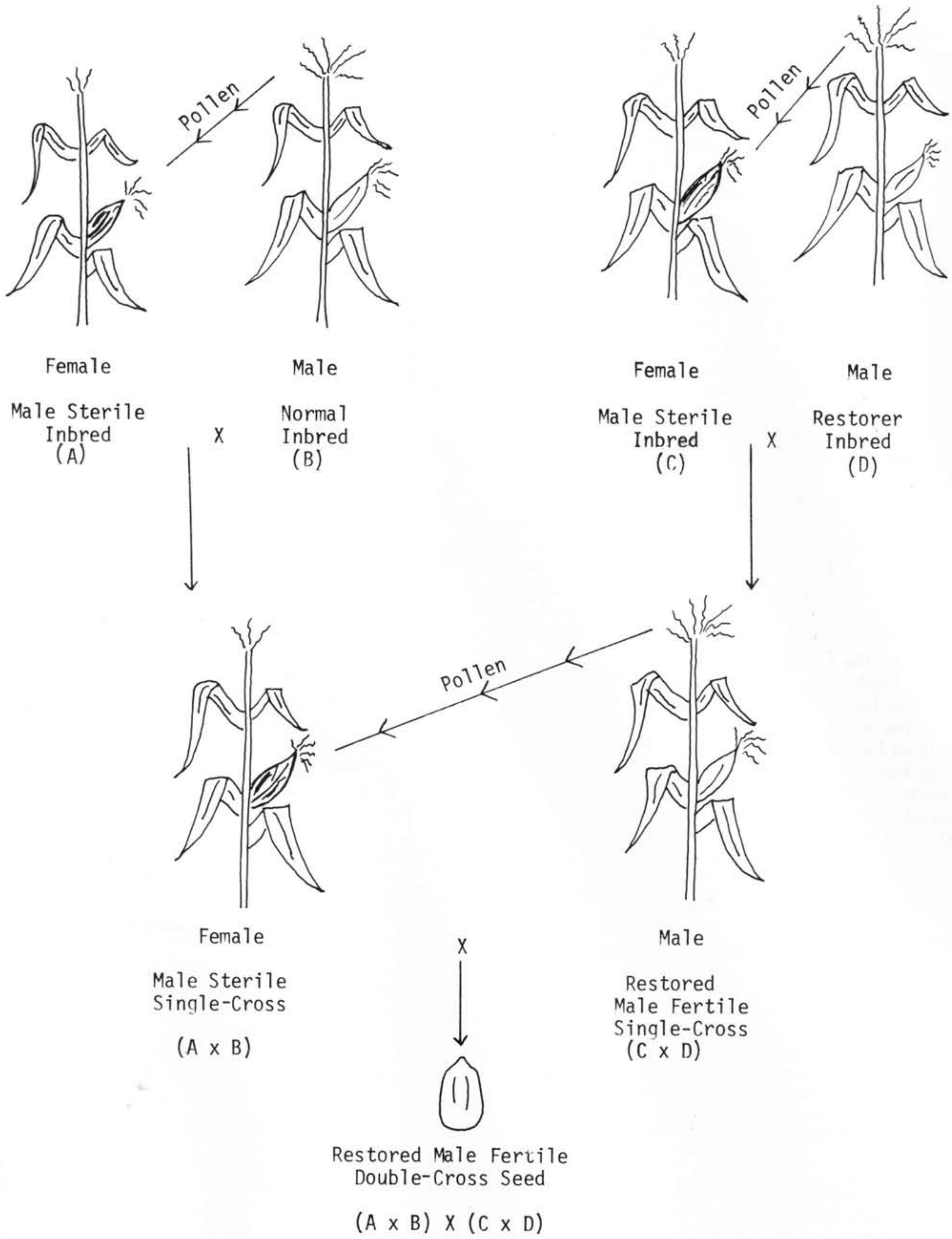

Fig. 2. Production of double-cross hybrid corn seed without detasseling, 1956.

In such fashion was the young man's grand idea of 1919/20 attained beyond even his expectations. Crossed or hybrid corn had come into its own. By 1963, the year of Jones' death, 95% of all corn grown in the United States was hybrid. The use of selected inbreds had been adequately demonstrated and its value was an acknowledged fact. The once necessary detasseling appeared to be something from "the good old days."

One innovator, two innovations: not a bad lifetime record.

That record is all the more impressive when one considers that the first innovation was made when Donald Jones was barely 25 years old, while the second was accomplished as he neared 60. There is a message of sorts in this simple fact, for in the contemporary world it serves as a reminder that while youth can be clever, it is the mature who possess wisdom. Donald Jones bulldozed hybrid corn into being with the cleverness and strength of the young. He moved fertility-restoration in corn on stage with the careful, deliberate steps of the experienced man who realizes the limitations of his strength.

Much more could be said about this quiet man. One could describe the routine details of his working life; his relationships with his colleagues; the scientific literature of his day—all terribly crucial to the research scientist. One could talk at great length about the controversies he engendered, controversies that are the normal complement of the career of one who operates on the frontiers of science.

There exist hidden facets in every man, qualities that drive him onward or, conversely, force him to retrace his steps. Such facets could be demonstrated readily in Donald F. Jones, a man who seldom wrote a long letter to anyone; a man, who, when making reservations for a hotel room always requested accommodations in the quietest part of the building.

All this, however, must be left for another place.

In summary, I think it appropriate once again to call upon Henry Wallace who said, in 1934:

> I am expecting profoundly significant work in corn genetics in the next 20 years which will have its eventual application to all life. . . .
>
> Most farmers still look upon corn as corn. But those who have worked with corn and studied it in all its intimate details for many years realize that corn is not merely corn. It is a composite of many things and can be molded in many directions. The possibilities with corn are almost as infinite as with humanity itself. The future is limitless as long as our desires are keen and our minds open.[27]

I believe Donald Jones would have approved of this statement. In his prosaic way, Henry A. Wallace was reminding us that it is the explorer and the visionary who carries the responsibility of civilizing mankind.

FOOTNOTES

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10. D.F. Jones, "Hybrid Vigor and its Meaning", *Scientific American, 121,* 1919, pp. 230-31, 239-41.
11. D.F. Jones. "Selection in Self-fertilized Lines as the Basis for Corn Improvement", *J. Amer. Soc. of Agron., 12,* 1920, pp. 77-100.
12. *Ibid.,* pp. 95-6.
13. *Ibid.,* p. 96.
14. *Ibid.,* p. 97.
15. *Ibid.,* p. 98.

16a. Agricultural Statistics, USDA, 1945, p. 38, 42.

16b. *Ibid.,* 1946, p. 29, 41.

16c. *Ibid.,* 1974, p. 6, 31-33.

17. Donald F. Jones, "Efforts to Increase Food Resources", In *Biology and Human Affairs,* E.M. East (ed.), Whittlesey House, 1931, p. 318.
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20. W.R. Singleton and D.F. Jones, "Heritable Characters of Maize, XXXV-Male Sterile", *J. Hered, 21,* 1930, p. 266.
21. *Ibid.,* p. 268.
22. Letter, D.F. Jones to Raymond Baker, Jan. 17, 1941, p. 2.
23. Deposition of Paul C. Mangelsdorf in Civil Action 63C597, Research Corporation v. *Pfister Associated Growers, Inc.,* U.S. District Court, Northern District of Illinois, Eastern Div., Feb. 26, 1964, pp. 98-102.
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25. H.A. Jones and Glen N. Davis, "Inbreeding and Heterosis and Their Relation to the Development of New Varieties of Onions", *USDA. Tech. Bull 874,* August, 1944.
26. Letter, Paul C. Mangelsdorf to John S. Rogers, March 6, 1944. (Defendant's Exhibit 35 in Civil Action 63C597; see also Reference (23) above).
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