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The Indian as a Corn Breeder

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That the Indian corn plant was a dominant factor in the development of the cultures of ancient America is admitted by all who have investigated the subject in any way. It was a plant ideally suited to hand cultivation in a land which had no animals that could be used to pull a plow. With it, the Indian had a way to a certain degree of leisure and economic security; without it, he usually lived on what nature provided and seldom knew what the next day would bring. When he grew corn, he had to keep his wits about him, and his reward was in proportion to his energy and intelligence. This combination of circumstances marked a straight road toward civilization.

The Indian abundantly acknowledged his debt to this plant. He established his settlements in places where it would grow well or fitted his migrations to its requirements. Significant times in its life cycle were set aside for special religious observances, its growth habits became a part of his folklore, its ear and tassel were conventionalized to adorn his pottery and his buildings, and the origin of the plant itself was woven into his religious mythology.

Interesting as it would be to go more deeply into the part which the corn plant played in the life of pre-Columbian America, I prefer at this time to consider another aspect of the subject, namely, the changes which the Indian made in the plant itself during the centuries while he was its custodian. Instead of reviewing what the corn plant did *for* the Indian, I wish to consider what the Indian did *to* the corn plant.

The logical way to begin this story would be to tell you exactly what kind of plant it was that the Indian first domesticated, but the interesting paths that we have followed in our search for this have all ended in a maze of uncertainty. Nowhere on earth has there yet been found any plant which fits the theoretical specifications of the wild progenitor of corn. We have here only the dubious consolation that the situation is almost as bad in the case of most other staple crop plants.

All possible sources which have been searched for direct evidences on the question have proved fruitless. There are many Indian stories about the origin of corn or of agriculture, but all of them involve some supernatural, or at least unnatural agency. On second thought, these stories could not be expected to hold much of scientific value. Any Indian who was present at that remote time when his race first began to cultivate corn would probably not be competent to make observations and records even if he knew the importance of what was going on; and the domestication of any plant has been such a gradual process, with its

future importance so little foreseen, that it is perfectly natural that the records of such processes will always be unsatisfactory.

Various early explorers have reported seeing wild corn or hearing of it, but the value of this evidence is seriously impaired by the generic use of the word "corn" to include many species whose seeds are used for food, by the incompetence of the untrained observer, and by the lack of any substantiating material evidences.

In spite of reports to the contrary, no fossils of the corn plant are known (7), and it is not very probable that any will ever be found. The structure of the plant and the conditions under which it has grown are not suitable for fossilization.

Archeological investigations have brought to light large quantities of grain, cobs, and stems of the plant, and these are useful in determining cultural affinities and sequences, but they are so recent that, as far as their bearing on our problem is concerned, they might almost as well have come from a cornfield of last year.

We come at last to the botanical evidences—to an examination of the plant itself to find what reminders of its past still linger in it, and to a comparison of it with the two wild grasses which seem to be its nearest relatives.

One of these is Tripsacum. Its six, seven, or more species occupy overlapping ranges from the latitude of Massachusetts, Michigan, and Nebraska southward far into South America. All of its species are perennial, and the forms with broad leaves resemble corn. There is also some resemblance between the two in the form of the inflorescence, but there are also some very distinct differences. The other genus is Euchlaena, better known under its common Aztec name, *teosinte*. There are two species, a variable annual one, native of Mexico and Guatemala, and a perennial one known from only a single locality in Mexico. The two look much alike, and either might easily be mistaken for corn; but they differ from it distinctly in the form of the female flowers and the fruits.

The close relationship of corn and teosinte, and to a less extent, Tripsacum, is further shown by their genetic compatibility. All ordinary kinds of corn hybridize with annual teosinte as readily as with one another, and the hybrids are fertile; but it hybridizes less readily with perennial teosinte. It is possible also to cross corn with Tripsacum, but a highly artificial technique is necessary, the percentage of crosses is very low, and the hybrids are not very successful(5). Only a single cross between Tripsacum and teosinte has ever been reported, but the corn-Tripsacum hybrid has been crossed with teosinte.

This genetic deportment may be partly explained by the cytological character of the three genera. The diploid chromosome number for corn and annual teosinte is 20, for perennial teosinte it is 40, and for the species of Tripsacum chiefly concerned in the experimental work it is 72.

A few other plants make contributions to the story, but from these three genera, Tripsacum, teosinte, and corn itself, has come the main body of evidence as to the nature of the primitive corn plant.

Tripsacum has been known to science for nearly 200 years. Its similarity to corn was early recognized, and at times there was some speculation as to the relationships of the two; but they are sufficiently different that any idea that Tripsacum is wild corn has been only tentatively advanced at any time.

Teosinte was discovered more than 100 years ago, but it was not until about 1875, or a little later, that it began to be seriously considered in connection with the origin of corn. The resemblance of the two species made it easy for the popular mind to assume that teosinte was the wild corn plant and that, at some remote time, the Indian recognized its usefulness, placed it under cultivation, and instituted a process of selection which resulted in the corn plant.

There are at least two published accounts of experiments—one of them made by Luther Burbank—which have purported to show that teosinte can be changed into a plant something like corn by selection over a period of years. These experiments are completely invalidated, however, by good evidences that, in both instances, they started with hybrids between corn and teosinte; but they have received enough publicity to confuse the thinking of many who have not weighed carefully the botanical evidences.

Among those who have accepted this idea at its face value are many students of the American Indian, and we find in various works on archeology and anthropology the statement that the Indian domesticated "a wild grass" and produced Indian corn. Sometimes the grass is specifically named as teosinte. Sometimes the statement is varied so that "three wild grasses" are said to have produced the "three principal varieties of corn." Inquiries as to what the three wild grasses were, or, for that matter, what the three principal varieties of corn are, have always been thrown back at some vague botanical authority without documentation.

The corn plant may have come from Tripsacum or teosinte, but there are some grounds for question. Both of these plants are more highly specialized in some ways than is corn, Tripsacum particularly so, and for either to develop into corn it would be necessary for it to back out some distance and take another road. It has been difficult also to see what inducement there would have been for the Indian to cultivate either of these plants in the first place. The seeds of both are small and completely enclosed in hard, horny, inedible shells, and the labor of preparing them for food would be far out of proportion to their value.

These objections are of sufficient weight that ten years ago probably no botanist well informed on the subject would have seriously considered the idea that corn came directly from either teosinte or Tripsacum, but two lines of evidence have considerably changed the situation in the last few years.

One of these is a better understanding of the ear of corn. It is undeniably a very remarkable structure, without an equal among the cereals for economic adaptability. We once thought that it had no morphological parallel in the grass family and felt obliged to account for it

by the lateral fusion of simple branches, the twisting of a spike, or some inexplicable monstrous development. We now know, however, that, at least in a qualitative sense, the inflorescences of such genera as Pennisetum, Cenchrus, and Setaria are built on exactly the same pattern as an ear of corn, and its explanation becomes comparatively simple (7). It is conceivable that a single mutation or simple combination of mutations in teosinte might have given to the growing point of the inflorescence and to the developing grain an increased vigor which would have laid the foundation for the development of a structure like an ear of corn.

There has been found also a characteristic of the seeds of teosinte which may have made them useful to primitive man before he knew anything about corn. When these seeds are heated, they pop like pop corn or the seeds of many other grasses, and the explosion is sufficiently violent to free the popped seeds from the surrounding hulls, thus making them readily available for food (1). This recalls a vague account of wild corn in Mexico 200 years ago and a tradition that the Indians first learned to use it for food when they found the parched grains in burned-over forest areas (6). Is it possible that the Indians did use teosinte for food until they developed a better plant from it? Or are we merely being treated in this story to another version of the Old World dissertation on roast pig?

It seems to me more likely that the ancient corn plant was neither Tripsacum nor teosinte but another plant which is now extinct or so rare that it has not thus far been found. It should be much like teosinte and probably less like Tripsacum, and it should have with them a common ancestry in some ancient stock which has now disappeared.

These views have developed to the accompaniment of a complex of theories to the effect that the corn plant originated as a hybrid between teosinte and some other species. This idea has been supported by several investigators and has taken different forms at different times (2, 3, 4, 5, 7). The only constant feature of these is that the plant had a hybrid origin and that teosinte was one of the parents. To find the other parent in theory seems to be about as difficult as to find the wild plant itself.

Although it sidetracks us from our main quest, there is still another theory of the relationships of these three genera which must be considered (5). Its chief tenet is that teosinte came from a hybrid between corn and Tripsacum. It is based upon the fact that the two plants can be hybridized if Tripsacum pollen is applied to corn silks which have been cut back to about an inch in length; and it is supported by an imposing array of genetic and cytological data. It is probably not simplifying this theory too much to say that it pictures teosinte as a kind of corn which has exchanged a few of its genes for corresponding genes of Tripsacum, a condition which might be expected if the first-formed corn-Tripsacum hybrid were back-crossed with corn.

For our present purpose, the chief significance of this theory is that it takes teosinte completely out of the picture as far as the ancestry of the corn plant is concerned. It is then no longer necessary to limit

our search for the wild plant to the regions where teosinte is native. The adherents of this theory now point to the Andean region of South America as the more probable place of origin. This has always been a welcome idea because of the high agricultural civilization of the Incas and the great diversity of types of corn which they grew, but we could never quite reconcile the origin of corn there with the general distribution of its nearest relative, teosinte, in Mexico and Guatemala.

It is now suggested that corn originated in South America and was later brought to Central America and Mexico, where it gave rise to teosinte by hybridizing with Tripsacum. The time of this event is even placed as late at 600 A.D. when the corn-growing Mayas migrated from the lowlands of Guatemala to the mountains where Tripsacum grows.

This concept turns our search to South America and revives interest in certain early reports that pod corn once grew there. Pod corn is a peculiar variety in which each individual grain is covered with husks in addition to those which normally cover the entire ear. The plant also has other primitive characteristics. It sometimes has mixed inflorescences and bears grains in its tassels; and, in the ear, it sometimes revives a long-lost characteristic and produces two grains where ordinary corn produces only one. But the primitive and the highly specialized are combined in it in such ways that it is difficult to say whether it should be regarded as a primitive plant or as an ordinary corn plant which has picked up a few primitive characteristics.

These are the principal imaginary pictures of the forerunner of our Indian corn plant. I cannot tell you which one of them is right. If I could, we could then discard all the theories and replace them with one fact. No one of them can at present be shown to be wholly right or wholly wrong. I like some of them better than others because they seem to employ more of the factual material and organize it more logically; but other investigators place different values on the facts and favor other interpretations; all of us change our views from time to time as the study develops.

I suppose that all who are working on the problem cherish the hope that the wild corn plant will some day be discovered, but the odds are none too favorable, and the search will not have been wholly fruitless if the plant is never found. In view of all this uncertainty, what are we to look for when we go into botanically unexplored regions in the hope of finding this plant? And, if some fortunate explorer should find it, how would he be able to recognize it?

This is an imaginary situation, and the answer to the question can be only an academic one, but I find it to be one of the commonest questions which people ask about the plant. The final judgment of such a plant will have to be left to those who are well acquainted with the range of variation in corn, teosinte, and Tripsacum as they are known at present, with their hybrids, and with a wide range of other species ordinarily placed in this part of the grass family.

Although I cannot give you a complete picture of the wild corn plant, I can describe some significant characteristics which it probably had.

To do this I note certain general evolutionary tendencies prevailing in this part of the grass family and consider the numerous abortive organs of the modern corn plant, which indicate structures lost in its evolution.

I should expect the wild corn plant to have something of the habit of teosinte; that is, it should be a profusely branched plant with many of the branches terminating in inflorescences. It would greatly simplify the problem if the plant were perennial by basal offshoots, as are many other grasses. Each inflorescence probably had both male and female flowers, but some were predominantly male and others predominantly female. The grains were probably surrounded by the chaff of the spikelets, as they are in most wild grasses and as they are in the ear of pod corn or occasionally in the tassels of all varieties.

The ears of the plant were probably small and branched, with the branches disarticulating or the grains breaking away from them at maturity. If a definite step had been taken toward the development of an ear with six, eight, or more rows of grains and few or no basal branches, this would greatly facilitate the breeding from this of the ear of corn as we know it; and steps morphologically parallel with these have been taken in many other grasses which have never been domesticated.

Whether or not the ear was surrounded by husks is more of a problem, but I think it not unlikely that it was at least partly surrounded and that there was a tendency for some of the ear-bearing shoots to shorten and develop at the expense of others.

A plant like this would already have developed some of the characteristics which make the modern corn plant dependent upon man's care, and it may have been already becoming rare and approaching extinction. If it grew in a favorable place, however, and had the perennial habit, it might have held its own for centuries if the Indian had not come to its rescue.

Wherever the domestication of the plant began, and whatever its exact form was at that time, it has apparently been under cultivation for many centuries. To change the self-sustaining, generalized wild plant into the extremely varied and highly specialized, but helpless plant that we know today must have taken a very long time—longer than anthropologists would, a few years ago, have granted to man in America. But new studies have pushed farther and farther back the date of his coming, so that the time requirements are now pretty well met.

Granting that we are not too far wrong in our picture of this plant in its undomesticated form, we may outline boldly some of the changes which have been made in it by man. The greater share of the credit for these modifications must go to the Indian races of long ago. There is no evidence of any fundamental botanical change in the plant within historic time.

When we speak of the Indian as a plant breeder we do not imply that he had any knowledge of the basic problems of heredity comparable with that which we have today. His technique was limited to selection, for he apparently knew nothing about hybridization. He undoubtedly observed pollen as he worked in the cornfields, and probably had his own

ideas as to its significance, but there is no indication that he knew anying about the part which pollen plays in the development of a grain of corn. On the other hand, there is at least one dependable account of how the Indians of the New England region, observing that varieties of different colors would mix if planted near each other, attributed this to the intermingling of the roots underground. Even if the Indian of a thousand years ago did not have a clear idea of the function of pollen in seed production, he was not far behind his white cousins across the Atlantic. The practice of definitely controlled pollination in the improvement of corn is an art now hardly more than twenty-five years old.

Improvement by selection is a different matter. Although the mechanism of the process is sometimes the despair of the experimental analyst, the fact remains that plants can be profoundly changed by selection. The Indian knew many things about the preparation of the soil and the planting, cultivation, and harvesting of the crop. He also learned to save a part of the crop for seed, and it is almost inconceivable that he would overlook the advantages of saving seed from the plants which best suited his purposes.

If other evidences were lacking, the large number of varieties of corn which were grown and kept separate from one another in various parts of the country would testify to the Indian's knowledge of selection as a method of plant improvement.

Probably the most conspicuous, and certainly one of the most significant morphological changes occurring in the corn plant since the beginning of its domestication has been the reduction of a complex system of branches to a simple stem with one, or at most only a few, ear-bearing branches. The comparatively simple plant in this respect is the aim of modern systems of breeding, because, in general, it gives the maximum yield per unit of area and facilitates harvesting; and its prevalence in some degree in practically all varieties developed by the Indians would seem to indicate that they gave it considerable attention. The ideal has been approached in varying degrees in different varieties, but almost all of them still have some basal tillers and some abortive ears on the main stem and in the axils of the husks of the functional ear. Differences in the degree of branching are hereditary, and, although the genetic analysis of these is difficult, both theory and practice indicate that the amount of branching can be reduced by selection.

If the plants which branched least and had fewest ears consequently had the largest and best ears, and the Indian exercised any degree of choice in selecting seed, there would be a constant tendency toward the simple stem with one or only a few ears. It is also conceivable that the primitive method of cultivation served to accelerate this process. The prevailing custom was to plant the corn in hills, beds, or occasionally in rows, so that many plants grew close together; then the soil was gradually heaped around the bases of the plants during the growing season. Under these conditions the plants which inherently showed the least tendency to produce basal suckers would have the best opportunity for superior performance, and, consequently, the best chance of being selected for seed.

This method of planting and cultivation had another effect about which we can speak with greater certainty. It is partly responsible for the plant's high intolerance of inbreeding. Self-pollination in corn is followed by a sharp decline in vigor. Teosinte and Tripsacum show no such effect. In all of these plants the pollen must travel through the air for some distance before alighting on the stigma where it is to be effective. In the freely-branching plants of Tripsacum and teosinte, where many inflorescences of identical origin are near together, there is a high probability of self-pollination and the maintenance of a homozygous condition. In corn, however, where many individual plants of different genetic constitution may grow in a cluster, the chances of cross pollination are high, and, if the plant is variable, as corn is, the result is a highly heterozygous condition. It is in the loss of this heterozygous condition, and probably through the separation of dominant characters conducive of vigor, that we get the well-known decreased vigor as a result of inbreeding.

The shortening of the ear-bearing branch until its leaf sheaths completely cover the ear is at least simulated in many other grasses, but we know very little about how it has been accomplished. This characteristic does add to the usefulness of the corn plant by giving the ear a protective covering which is easily removed by hand, and thus it had an artificial survival value as the plant was being domesticated. It may have been foreshadowed in the wild plant; but, if so, it is to be regarded as a detrimental character under natural conditions because it prevents seed dispersal. The degeneracy of the chaff around the individual grains probably accompanied the retraction of the ear into its covering of husks, and pod corn recalls this condition.

If the plant was originally a perennial, as I think it must have been to have been able to survive in spite of its handicaps, somewhere along the way it assumed the annual habit, thus carrying out a recognized general tendency in the evolution of plants, especially under cultivation.

There are innumerable varieties of corn, but there is a uniformity throughout all of them in what we may call the fundamental pattern of the plant—the separation of male and female inflorescences, the highly specialized ear-bearing shoot, and the tendency toward an otherwise unbranched stem. This would indicate that the greater part of its development under the direction of man was accomplished in a single locality and that its general distribution came late in its history. The development of the numerous agricultural varieties, differing chiefly in the size of the various parts and the color and chemical composition of the grain is a recent and still progressive thing.

The Indian's place in a world-wide anthropological pattern still presents many unanswered questions, and it taxes the imagination to picture what his destiny in America would have been if the coming of the white man had been delayed a few thousand years longer. Our histories of what we call the western civilization pass by the story of the Indian races as an incident outside the main stream of progress, and the Indian himself as hardly more than one of the physical obstacles to the exploitation of the American continents. But the Indian did send

into this stream one strong tributary. He took from the wild state a plastic grass plant of some sort and, by a process of breeding unsurpassed anywhere in the world at that time, he made of it the cereal which is so varied, so adaptable, and so efficient in turning raw materials into food that it has dominated American agriculture for 2,000 years and bids fair ultimately to extend its influence all over the world. This achievement makes the Indian worthy of a longer chapter in human history.

References

The following is not intended to be a complete bibliography. Those desiring more detailed references should consult some of the more recent papers listed below.

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