SCIENCE:

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CORN CANE.*

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IT IS the object of this paper to show from facts recently established that about one-half of the available food products of Indian corn are now wholly lost to us,—lost because unused and hitherto unknown to exist.

If it can be proved that what is thus lost can now be readily recovered, and not only so, but that it is recoverable as a new product from this plant, giving it an entirely new value, such attainable results will clearly be seen to be of great economic importance.

This consideration is entirely aside from the fact that much waste, which might be avoided, is often incurred in the production of our ordinary corn crop. Although great strides have been made within the past twenty-five years toward better farming in this country, by the adoption of improved implements and more systematic methods, it cannot be disguised that our treatment of maize, as an agricultural plant, is yet very defective, chiefly, as it seems, because its true nature and requirements are but imperfectly understood.

The tropical luxuriance of an American corn field, in the full tide of its summer growth, is something to awaken admiration; but the indulgence of such sentiment is commonly left to the artists and poets and the few students of vegetable physiology among us who have noted carefully the marvellous mechanical structure of the plant, its wonderful vigor and the perfect symmetry of its growth.

But all this goes for nothing at the harvest, when, in point of value, the dry, skeleton stalks are brought in contrast with the rich golden corn; and therefore the steady aim in cultivation has been to repress stem growth and increase the yield of grain.

No good reason is perceived why nature should so stubbornly persist in mounting the magnificent ears, which alone we set store by, upon solid culms twelve and fourteen feet high. And so, we have come to regard the huge stalks as the embodiment of much valuable constructive energy which might otherwise have been more profitably employed. True, this theory does not pass without protest; but it is satisfactory as shifting upon nature the responsibility for a condition of things which justifies the recent criticism of a surprised visitor out west, and complacently accepts it as true, that "Indian corn growing is the only business in which a man can waste forty-five per cent of his capital and yet make a living."

Certainly our appreciation of this plant and our treatment of it would be different if we knew it better. Our acquaintance with it is not yet of that intimate kind that we have with the cereals and forage plants that migrated with man from the cradle of the human race. It is true that maize has been known to civilized man, more or less, for about 400 years. Its grain is by far our most important food staple. Its production now equals about 2,000 millions of bushels annually in this country alone, in value, about 700 millions of dollars. Our agricultural system is, in a measure, shaped by the requirements of the successful growth of this crop, and we are credited abroad with knowing all that is worth knowing about it.

It has been introduced, also, into all regions of the earth where it can profitably be grown. In its already recognized relations to the welfare of man, no acquisition from the vegetable kingdom has ever been found to equal it in value. Yet the obligation thereby implied to investigate thoroughly its nature and properties has most unreasonably been avoided by those competent to do it.

It has been taken for granted, apparently, that this plant has no uses beyond those already known. In this country, at least, its established rank among the cereals is so unique and unrivalled, and its capacity to supply all reasonable wants within what we have come to regard as its proper sphere, have seemed so complete as to awaken no desire for further investigation looking toward the discovery of any possible new uses of the plant or its growth and development under any other than the usual conditions.

Some ten years ago the writer of this shared with some others in the belief that both maize and the then newly introduced sugar millets or sorghums were entitled to a prominent place among sugar-producing plants for those regions of the temperate zones which are characterized by a sub-tropical summer climate. The experiments which seemed to justify such an opinion, however, were necessarily very incomplete, and covered a period of only about two years.

In the popular estimate of the comparative value of these plants the Cape millets or African varieties of sorghum were given the preference. This was also the view taken at the Department of Agriculture at Washington, to which, by special invitation of the Commissioner, the methods and results of some preliminary tests of mine were submitted for examination and report. It is outside of my present purpose to refer to those first experiments further than to say that they were repeated very successfully at the department by the chemist in charge and by others competent to do the work elsewhere, and the reports show that the conclusions first reached were abundantly confirmed.

In the years following experiments in sugar manufacture from sorghum began to be prosecuted under the patronage of the general government,—and of some of the State governments likewise,—and they have been continued with very variable results in different localities, but with the promise of permanent success, chiefly under the favorable climatic conditions prevailing in our southwestern States, especially Kansas and the Indian Territory.

The experiments being thus limited to sorghum alone, the value of maize in this connection was left entirely an open question. Practically, its claims were completely ignored.

What follows is simply a brief narration of work performed and of results reached in the course of an investigation begun and conducted throughout by myself in a private way to determine this question. It covers a

*An account of the results of an investigation concerning the value of Indian corn as a sugar-producing plant under new conditions of growth and development.

period of the last eight years, or from 1884 to 1892, inclusive.

The motive for undertaking it was furnished in the fact that in the previous examination of this plant I had noticed that it exhibited some remarkable peculiarities, the exact nature and causes of which were unknown, and to which no former investigation furnished any clue.

When it began, I had samples of different varieties of corn growing under different conditions as to soil and culture and planted at different times. In the course of tests made in the fall of the year 1884, the results of which were chiefly of a negative character, except as proving that the exceptional richness in sugar, which, in a few instances, had been noted before in some samples, did not attach to any particular variety of corn, and that the accumulation of sucrose or cane sugar in all sorts, both of field and sweet corn, was uniformly progressive with their growth after a certain period, and reached its supposed maximum always, as had previously been noted, just before the grain began to glaze or harden. In all sorts, likewise, the fact was confirmed that after that period had passed, vital activity in the plant almost immediately ceased, and all the soluble organized materials lodged within the cells of all parts of the structure, except the grain, rapidly ran down into lower forms successively, and in a few days totally disappeared, leaving in the stalk only a vapid watery juice, which in its turn as rapidly evaporated out. Of course, only the dead, dry stalk remained, in that condition a very type of worthlessness, except as a feeble support to bear up for a time the the ripened ear.

But it was noticed that some plants of the same age and sort as these shrivelled and dead ones, grown alongside of them in the same plot, from which, however, the immature ears had been plucked some time before, did not share in that condition. Their stems and leaves, and especially the leaves springing from the upper joints, were yet green and vigorous, and when samples of them were cut it was evident that they had not diminished in weight as compared with other plants cut before the grain had matured. Some of the juice was pressed out for examination, and to my surprise it showed qualities much superior to any previously noticed that season. These indications were more than confirmed when the sample was subjected to analysis. I give below the results of the tests to determine the relative percentages of the sugars and other solids contained in this juice, as taken from my note book at the date of this first experiment made upon maize in this condition, Sept. 10, 1884.

The variety was the common yellow Dent corn usually grown in this locality (western Pennsylvania).

	Sample Sept. 10, 1884, Specific gravity of juice, 1.071.	Sample Aug. 23, 1884. Specific gravity, 1.048.
Cane sugar,	13.84 per cent	6.70 per cent
Glucose,	1.07 " "	2.50 " "
Organic matter not sugar and salts,	2.39 " "	1.80 " "
Total solids,	17.30	11.00

I have placed alongside of this for comparison, in the second column (above), the average composition of the juice of plants of the same variety, taken at the time when the grain was yet soft and when the cane sugar percentage was usually at its highest at that stage.

The experiment was speedily repeated upon another plant in the same condition and with almost precisely the same results. An increase of sucrose was indicated exceeding by nearly 100 per cent the normal as found in plants at the period of their life when it ordinarily has reached its highest limit.

This was a remarkable result in itself, but its chief significance seemed to rest in the fact that the high percentage of sugar was in some way correlated to the condition of arrested development of the grain.

Attention was at once directed to some naturally sterile plants, those upon which no ear had formed. These were still alive, green and vigorous, and closely resembled those from which the immature ears had for some time before been removed. Experiment soon disclosed an almost complete identity between them in the chemical composition of the juice. The only logical interpretation of this, supposing the results to be constant, was that the suppression of vital activity in the ear induces functional changes in other parts of the structure, especially in the stem in which the reserve products are chiefly lodged, whereby the existence of the plant is prolonged and a new direction given to the unspent energy which would otherwise have been consumed in the final development of the seed.

Taking only the totally abortive plants, abortive as to the seed, into the account, an analogue to them seemed to exist in the sugar cane, which produces ordinarily no seed at all. The relationship of the latter to Indian corn is very close. Was it possible that the arrested development of the seed, however brought about, conditions the more active building up and storage of the soluble carbohydrates, and especially cane sugar, within the cells of the stalk which seem so highly specialized for this end in both?

If so, it was hardly credible that such a circumstance should have eluded observation heretofore. Yet to that conclusion the facts so far gathered seemed to point.

If it could be fully verified as a physiological trait, under the specified conditions, it was easily seen that it would result in an enormous gain in the productiveness of the plant in two opposite directions, two full crops instead of one, the grain almost equal in amount and, superior in nutritive value to the ordinary hard corn, and instead of an almost worthless mass of dead fibre, fully developed canes, in full life and vigor, richly charged with true cane sugar.

It thus began to be evident that a new principle in the economy of the plant, unnoticed before, was in action, controlling its activities under the changed conditions.

The suggestion that the extraordinary accumulation of sugar in the juice was apparent only, and not real, the result simply of concentration by evaporation from the stem, had to be dismissed at once, for it is well known that true evaporation can take place only from dead cells, the process involving the destruction of their organized contents and not their accumulation, and is followed by immediate loss of weight.

Enough had now been learned certainly to stimulate to further research, but not enough to establish the absolute constancy of the new results reached under variously modified influences, all of which could not manifest themselves during a single season of growth. But if a thorough investigation during a series of years subsequent, covering all important points, should be found to confirm fully the outcome of these first experiments, it would be regarded as decisive. Nothing less would dissipate the incredulity with which a disclosure of the facts would be received when four hundred years of accumulated experience of the plant in cultivation, in every quarter of the world, had failed to bring it out.

To the self-imposed task of doing this work, self-imposed because neither inclination nor constraint seemed to impel any one else to undertake it, much of my time has been given during the past eight years.

In brief, it may now be said that the outcome has not only abundantly confirmed the conclusions first reached,

but shows that there can be no middle ground between the common estimate of the plant and that which a logical interpretion of all the facts now disclosed forces upon us.

Each successive season a fresh series of analyses and practical tests were made and put upon record, beginning with that stage of the development of the plant, when the percentage of cane sugar had previously been supposed to have reached its maximum, and extending them through the after period of juice-ripening, brought on by the timely separation of the immature grain, up to the time of frost. It was found that the saccharine strength of the juice, under the new conditions, constantly increased in a fixed ratio, and that the life of the plant was prolonged from a month to two months beyond the natural period.

(To be continued.)

THE ASTRONOMICAL EXHIBITS AT THE WORLD'S FAIR.

THE Astronomical Exhibits at the World's Fair at Chicago represent fairly well the present state of the science of astronomy. But they are scattered about in the various buildings so as to make it difficult even to find them all, to say nothing of systematic study and comparison of them one with another. In a general way, the most important astronomical displays are to be found among the educational exhibits, which are located in the west and south galleries of the Manufactures and Liberal Arts Building. In the exhibit of Harvard University, in the south gallery, is a splendid collection of astronomical photographs made by the Harvard College Observatory. Especially interesting are several photographs of stellar spectra and of nebulæ and clusters. One photograph of a portion of the moon's disk represents an enlargement of over one thousand diameters. Nowhere else can be found a better illustration of the great usefulness of photography in astronomy. The collections of Draper and Langley are to be found in the exhibits of the University of the City of New York and of the Western University of Pennsylvania. The four-inch almacantar, which is the first one constructed and used by Dr. Chandler, is in the exhibit of De Pauw University. The exhibit of Johns Hopkins University contains a fine collection of diffraction gratings and photographs of spectra by Professor Rowland. In the German Educational Exhibit, in the west gallery, are specimens of the famous Jena optical glass, the original spectroscope of Kirchhoff, and some fine mathematical models by Brill. Here is also shown the magnetic apparatus of Gauss and Weber. Near by, in the English Exhibit, is the display of the Royal Astronomical Society, containing a large number of astronomical photographs by Roberts, Gill and Abney, and still others from the Royal Observatory at Greenwich. Boeddicker's drawings of the Milky-way and Dr. Common's five-foot glass speculum are in the English exhibit. The latter is unsilvered and has evidently been placed with greater care to secure safety than visibility. In the Swiss Exhibit, in the main aisle of the Manufactures Building, is a display of instruments by La Société Genevoise.

The exhibits of the American makers of astronomical instruments are in the north gallery of the Manufactures Building, just over the main aisle. Warner and Swasey show a fine twelve-inch equatorial telescope, with smaller instruments, and also the mounting of the great forty-inch Yerkes telescope, which is set up at the north end of the main aisle. The appearance of the great telescope gives an impression of symmetry and strength. The lens for it is being made by Alvan Clark & Sons, of Cambridgeport, Mass. They report satisfactory progress, but say that it will not be finished for a year or more. The Clarks, by the way, make no exhibit at Chicago. J. A. Brashear, of Allegheny, Pa., exhibits the stellar spectroscope for the Yerkes telescope. He also shows an eighteen-inch and a fifteen-inch objective, gratings, specula, etc. G. N. Saegmuller, of Washington, exhibits a variety of instruments of precision, among which are a nine-inch equatorial telescope and a four-inch steel meridian circle. The exhibit of the Gundlach Optical Company also deserves mention. The American instrument-makers, as a whole, make a most creditable showing. The displays of the foreign instrument-makers are, many of them, located in the Electricity Building. Schott und Genossen, of Jena, show a large number of specimens of optical glass, and among them are two twenty-three-inch discs of the celebrated Jena glass. Merz, of Munich, shows two equatorial telescopes and several telescopic objectives, the largest of which is ten inches in diameter. The Repsolds, of Hamburg, seem not to be represented—a fact much to be regretted.

Dr. Gill's interesting stellar photographs are in the Cape Colony Exhibit in the Agricultural Building, and the Lick Observatory display is in the educational department of the California State Building, and is strangely enough mixed up with the kindergarten exhibit there.

The U. S. Naval Observatory Exhibit is a small observatory located northeast of the Government Plaza, and is in charge of Lieut. A. G. Winterhalter, U. S. N. There are a small equatorial telescope, photoheliograph and many smaller instruments. The Weather Bureau Exhibit, a short distance to the west, is well worth a visit. The exhibit of Coast Survey apparatus, in the U. S. Government Building, is full of interest, from the geodetic standpoint.

SCIENCE TEACHING IN SECONDARY AND PRIMARY SCHOOLS.

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IT has long been a dream of scientists that the time would come when the elements of natural history and of the physical sciences would be taught in secondary and primary schools. To thinking people it does not seem necessary to argue that every boy should be instructed in the elements of chemistry, natural philosophy, botany, geology, zoölogy and physiology. To persons not teachers, it would seem no difficult matter to find a place in the school curriculum for the elements of the above sciences. But it remains true that they are not taught, or taught to such an extent, and in such a manner, as to produce results entirely worthless.

Why is this condition of things prevalent? Why, after all that has been said and written, is there is no change for the better? The answer seems to be this: The elements of the sciences are not taught in elementary and primary schools for the reason that the teachers themselves have never been taught, and without instruction they feel that to attempt to teach these branches they would be blind leaders of the blind. More than this, the schools whose special duty it is to train teachers for primary and secondary schools, have not begun to do any real work in the line of science instruction. The sciences in these schools are so placed in the background that practically no training at all is given in them. It is then no wonder that the graduate of such a school does not feel capable of giving any instruction in even the elements of the sciences. To demonstrate the above statements the catalogues of the Pennsylvania State normal schools will be examined, and certain results tabulated. It will be seen that the teachers of *arithmetic* and *grammar* far