The Future of the Sugar Beet

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In his excellent article entitled "The Sugar Beet: Product of Science," published in the Scientific Monthly, March, 1949, Dr. George H. Coons has a summarizing section in which he says, "The sugar-beet industry is now faced with economic problems that threaten its survival."

This is a thought-provoking and quite conservative statement. It deserves further consideration by the members of The American Society of Sugar Beet Technologists. "It is possible that the future status of the industry will depend, at least in part, on. the combined and varied researches of a group of workers such as here assembled. And, it is not improbable that, in spite of technological progress in the culture, processing and utilization of the sugar beet, the economic and political turn of events in the world may decide the ultimate status, if not the fate, of this important crop plant. In these times we frequently observe that technology, economics, sociology, and politics are working at cross purposes."

The future of sugar is secure. This is self-evident. Sugar is basic in our whole economy. There is no substitute. It is a food. It is fuel. It is a foundation chemical in the manufacture of innumerable industrial products. As stated by Dr. R. C. Hockett of the Sugar Research Foundation, "sugar is the largest dry cargo in international trade—the only pure organic chemical which has a tonnage production in the United States in excess of 14 billion pounds annually." Without doubt the total use per capita of sugar in the world will increase. Whereas the annual consumption per capita in the United States is around 100 pounds, there are millions of people with a yearly consumption well below 50 pounds. These peoples constitute a potential market.

Sugar needs less defense than does the beet as a source of sugar. Let us not worry too much over the fact that some few in the medical world are telling parents to give their children less sugar because of its injury to teeth. Such considerations are mere trifles and have little bearing upon the future of the sugar beet.

Man has become increasingly energy-conscious. Material progress down through the years has depended upon the harnessing and transformation of energy. Coal and oil, fast dwindling, have been our principal sources of energy for industrial development. Man-power, horse-power, ox-power—these represent the energy derived from foods. The energy in foods is transformed solar energy. We speak, move and think. These processes require energy. The food we eat is the source of this energy. We are re-evaluating crop plants in terms of calories, i.e., energy. We have witnessed recently an earth-shaking step—the fission of the atom—in which prodigious quantities of energy are liberated. The efficiency of all machines and operations is an energy-relation. Victory goes to the combatant who has the largest stores of energy and utilizes them with the greatest efficiency. Wars are fought to secure access or control of coal, oil and rich agricultural lands—all potential

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sources of energy. In the struggle of humans for existence, in a world whose population is increasing at a more rapid rate than food production, the fight will increase in intensity for basic energy-yielding materials. There is a philosophical implication, with increasing import, which may be stated as follows: The waste of energy in any form is the very essence of evil; its conservation the essence of good.

Living organisms—all plants, both green and non-green, and all animals, including man—need a continuous source of energy. Except a few special types of bacteria (chemosynthetic organisms) , this energy is derived directly from the oxidation of foods, the carbohydrates, fats and proteins. Foods are organic substances manufactured from inorganic ones by green plants, and only green plants. The raw products in the manufacturing process are two low-energy compounds, water and carbon dioxide. In the cells of plants which possess a green pigment, chlorophyll—water and carbon dioxide are chemically united to form a simple sugar, a relatively high-energy compound. The chemical reaction, that is, the combining of water and carbon dioxide to form a sugar, requires energy. This energy is that from light; it is solar or radiant energy. Chlorophyll absorbs the light energy, and in some manner not understood, it becomes available to the cellular protoplasm, and is utilized in the work required to bring about the synthesis of a sugar from water and carbon dioxide. The sugar molecule represents a supply of energy —chemical energy, transformed solar energy. The process of converting solar energy into chemical energy by chlorophyll-bearing plants is known as photosynthesis. We may well regard photosynthesis as the world's most important chemical action. All the carbon in plants and animals is derived from the $C0_2$ of the atmosphere in the photosynthetic process.

For millions of years this energy conversion by green plants has been going on. The energy in coal, petroleum, oil shale and natural gas, appropriately called "fossil energy," represents the energy of light which fell upon . green plants which clothed the earth ages ago. Photosynthesis is a process which changes solar energy to forms of energy usable by plants and animals as food, and as fuel for industrial development. It seems that we have been slow in realizing how strict our dependence is upon the sun as the great source of energy. Farmers, primarily the growers of green plants and of animals which live on green plants, constitute a group in our world economy which produces the only living organisms possessing the power of converting solar energy into the potential energy of organic compounds. This is no mean responsibility. It gives support to the campaign orator speaking to a rural audience when he says, "The farmer is the backbone of the country," but it is doubtful whether he understands the full meaning and basis for the statement.

In the temperate zone about ly_5 billion kilocalories (1 kilocalorie is 1,000 calories) of the sun's radiation come to each acre of land or water surface per year. This is approximately 20 million per day or about one kilocalorie per square foot per minute. In the Tropics this figure is greater, and, moreover, the growing season is longer. Spoehr states this in a different form when he says that "The solar energy received on an acre of land during a growing season of 90 days is equal to the energy contained in 243 tons of anthracite coal." Wigner asserts that "The total amount of coal under the ground in the United States has somewhat less heat content than the United States receives as sunshine during a single year."

Unfortunately, the green plant is a very inefficient machine in its transformation of energy. Its efficiency has been measured in various ways. An acre of Wisconsin aspen trees produces in a year about 2 tons of wood. When these 2 tons of wood are burned, Sy_2 million kilocalories are yielded. This represents somewhat less than 1/10 of 1 per cent of the total solar energy which fell upon the acre during the year. Transeau calculated the efficiency of photosynthesis in corn. He considered an acre of corn growing in north-central Illinois and yielding 100 bushels during a growing season of 100 days. Taking the grain, leaves and roots, he calculated that the corn plant used about 1.6 per cent of the available solar energy. The harvested grain alone represented about 0.4 per cent of the total radiant energy which fell on the acre during the 100-day growing period.

Suffice it to say that green plants, including crops, utilize but an extremely small fraction of the total solar energy coming to the area upon which they grow.

In spite of this low efficiency of energy-conversion by plants, the annual total world production of the products of photosynthesis amounts to something over 2,000 times the yearly production of steel, which is 100 million tons. Schroeder estimates that the green plant life of the world's land area of 37 billion acres fixes about I81/9 billion tons of carbon per year.

Logically, we come to the following significant question: What is the relative efficiency of various crop plants as converters and storers of solar energy? If certain ones are more efficient than others, then it follows that these should be given some priority in our agricultural planning. Moreover, a crop which yields by-products capable of being utilized as a source of energy warrants more favorable consideration than one whose by-products are nonutilizable.

Various methods have been employed to measure the energy-value of the major crop plants. For example, Monier Williams gives the yield in gallons of 95% alcohol in the following crops: Rice 44, wheat 50, barley 59, corn 72, potatoes 164, sugar cane 306, and sugar beet 353. As with sugar cane, potatoes, corn and other cereals, the sugar beet ranks very high as an efficient converter and storer of solar energy. This relatively high efficiency, duly recognized, should firmly establish the sugar beet in our economy—in a world in which energy in every form is becoming increasingly critical and vital.

Today the most unexpected discoveries in science may occur. They come upon us in rapid succession. How many of us ever dreamed a decade ago that man would be able to bring about the fission of the atom, and utilize the energy wrapped up in that infinitesimally small particle? In other fields, how many of us anticipated two decades ago how drastic the changes would be in our economics, sociology and politics, both national and international?

Let us discuss for a moment the various changes which could affect the status of the sugar beet industry. Research on the fundamental process of photosynthesis is now active in about a dozen laboratories. Biochemists are of the opinion that there is no theoretical reason why the synthesis of a simple carbohydrate cannot be done- Suppose we engaged a group of several hundred qualified research workers, and provided them the sum of 2 billions of dollars, an amount expended on atomic research, it is not unlikely that a way would be found to do in the laboratory and factory what is now accomplished in the green plant. Daniels states: "If some one had asked me to guess ten years ago which would come first, atomic energy or photosynthesis without the living plant, I would have guessed the latter." Suppose it becomes possible to convert solar energy into the chemical energy of the sugar molecule so cheaply that we could use sugar not only as food but as fuel. If these technical discoveries come to pass, undoubtedly they would have a profound effect on the sugar industry.

The population of the world is increasing rapidly, an increase unfortunately uncontrolled. This will affect land utilization, international relationships and agreements, and intensify the struggle for sources of energy. Who knows what these relationships and agreements in the years ahead will bring? In truth, the fate of the sugar beet depends greatly upon the turn in international relationships, and the relative strength developed by conflicting social and economic ideologies. Suppose the present trend which started in the early 30's in the United States toward a controlled economy, and in other countries somewhat earlier, with its acreage and production allotments by geographical areas, its price controls, its subsidies, and what-have-you, continues, we may have the experience of seeing economists in certain high places saying to those sugar beet growers in areas where yields are comparatively low: "Do not grow sugar beets. It is to the best interest of our whole economy that you grow wheat or corn or flax." Or they might say: "We in the United States should grow no sugar beets. Sugar should be produced in the tropics."

The exploitation of tropical areas is bound to occur. Salter estimates that a "total of one billion acres of tropical and subtropical soils may be used in calculating world soil potentialities." There is progress in the control of tropical diseases, and general improvement in living conditions in the tropics, both of which will tend to attract capital investments to these areas. Moreover, tropical agriculture is becoming mechanized. These changes may bring about a phenomenal increase in sugar cane production—a development which would undoubtedly react upon the status of the sugar beet. Particularly would this be the case should extant theories laying stress on the economic use of the world's land areas be put into effect.

There is serious discussion in the world about the race between population and food supply. Production, distribution and use of food have become a main concern in a world whose population is increasing rapidly, and even now sees one-half of the world's peoples on a sub-standard nutritional level. Dr. H. R. Tolley, director of economics and statistics, Food and Agricultural Organization of the United Nations, estimates that food needs in 1960 will call for a 12 per cent increase in sugar production for the world as a whole in order to bring nutrition to the levels assumed to be necessary. The greatest needs will be for milk (100% increase) and meat (46% increase). Apparently, the bottle-neck in the world food situation is protein shortage. Peason and Harper estimate that, of the total food consumed by the world's population, grain and grain products make up 73% (dry basis), vegetables and fruit, 12%; sugar, 6%; and all animal products, 9%. It is of interest to note that the proportion of total human food derived from animal sources varies greatly in different areas of the world. For example, in Asia it is 3%, Africa 4%, South America 16%, Europe 17%, North America 25% and Oceania (including New Zealand and Australia), 36%.

Based on the estimated food needs of the world in 1960, it is believed that the requirements can be met for sugar, and for roots and tubers, and probably cereals, by proper management and utilization of present farm lands. This supposes a stepup in erosion control, in plant breeding, in use of fertilizers, in control of insects, plant diseases, and weeds, in mechanization, i.e., in technological improvements. The other classes of foods will fall short of needed production, unless extensive new land areas are brought under cultivation.

It is well understood by the members of this Society that in judging the value of the sugar beet industry to a community indirect benefits as well as direct ones must be considered. "The culture of sugar beets in a district raises the standard of all agricultural methods and increases the stability of agriculture in the entire district. The successful culture of sugar beets is not consistent with poor farming. It is a culture which requires thoroughness, and sooner or later this is reflected in the growing of other crops. Without reference to sugar as such, beet culture is for many reasons essential in intensive agriculture. And then of major importance is the fact that the sugar beet, considering not alone the sugar, but the by-products, is a relatively efficient converter and storer of solar energy. This is a basic consideration."

Looking ahead to the world food needs in 1960, foods rich in proteins appear to present a particularly serious problem. By virtue of its important role in supplying by-products which foster the livestock industries, the sugar beet occupies a favorable position. This situation emphasizes strongly the urgency of complete and efficient use of all sugar beet products. By so doing, we can place ourslves in a favorable position in any agreements as to the relative merits of the sugar beet and sugar cane. But, these are facts not fully understood and appreciated by those who may have influence in shaping the destiny of the sugar beet industry in this country. It seems obvious that the membership of this Society has a responsibility here. Our most effective propaganda will be technical progress leading to higher yield, lower costs, more complete use of by-products, and more emphasis on all the indirect benefits of the crop. We must have stands of beets which will capture a maximum amount of the radiant energy that comes to a unit area. We must be conscious of the fact that there is a very basic reason for the complete utilization of all by-products. Let us not forget that potential yields are far below the average; that the discrepancy between maximum yields and average yields in every beet territory is far too great.

We have made progress. With this you are familiar. Surveys in certain territories show that the man hour requirement to grow and harvest an acre of sugar beets dropped from 120 hours in 1915 to 66.85 hours in 1948. In field and factory, from seed bag to sugar bag, there has been progress and increased efficiency. Geneticists, agricultural engineers, plant physiologists, entomologists, botanists, plant pathologists, chemists, factory operators—in fact, technicians of every sort have made their contributions. These are the individuals who make the American Society of Sugar Beet Technologists.

It behooves the American Society of Sugar Beet Technologists to continue in its efforts to increase the efficiency of the sugar beet industry. I speak of efficiency in the fundamental terms of energy transformation. This energy transformation begins with the first expenditure of human energy and the energy set free in the combustion of gasoline during preparation of the seed bed. It proceeds throughout every operation in the growing, harvesting, processing and marketing of the crop. Our continued usefulness in the economic scheme of things, and it may be our survival, depends upon an increasing efficiency in this transformation of energy from bag of seed to bag of sugar. The industry will experience ups and down as in the past. But, if we do our part, final judgment will be a general and widespread vindication of the sugar beet. The direction taken and the quality of our technological researches will go far in maintaining and improving the status of the sugar beet in American agriculture. It is not the primary function of this Society to propagandize. Rather, we must furnish the ammunition to be used by the proper individuals and organizations who believe in the sugar beet and are working in its behalf.

The sugar beet industry is no longer an infant. It is now a fairly strong and more or less independent young man. In spite of the usual troubles which all infants experience, and at times improper and inadequate nourishment, the child has grown and attained an age past adolescence. Its parents were of the sturdy pioneer type who believed in free enterprise. They nurtured and cared for the child in much the same way as did the great and great-great European grandparents. Doctors did not always properly diagnose the ailments nor give satisfactory treatment, due principally to inadequate knowledge. Then, too, the environment in which the child developed was at times difficult and unpredictable; there were some bad boys in the neighborhood, and the parents of these boys sometimes had little sympathy with the young fellow. In fact, they had no use for him, and would, if they could, banish him from the community. The young man now finds himself in an environment where controls prevail; his behavior is carefully scrutinized both by his neighbors and his parents. The money he earns and spends and saves is under strict supervision. Sometimes his ambitions are thwarted, and his plans for the future dashed liberally with cold water. Yes, our youth entered college. His curriculum was a stiff one. He had many things to learn—engineering, agronomy, chemistry, entomology, plant pathology, genetics, soils, and even weed control. Sometimes funds were low, and his studies suffered. Tuition fees were raised. He entered the army, and we believe his services were a credit to the country. Orders from headquarters were frequent and often confusing and conflicting. But he came through the conflict with only minor wounds—but no Purple Heart.

Yes, our infant is now a young man. For his age, he is experienced, fairly strong and energetic, and has attained a state of precarious independence. He has both friends and foes. Most certainly, his education is not complete; he must always remain a student; he must improve his working methods and habits; be progressive, efficient, frugal, and even conscious of his obligations to the complex and changing community life and world in which he finds himself. He must, in fact, carve out for himself a career in this complex world of conflicting ideologies which will make him an indispensable man.