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THE AGRONOMIST'S PART IN THE WORLD'S FOOD SUPPLY[1]

The welfare of mankind is intimately bound up with the world's food supply. Not that man can "live by bread alone," but he is unable to devote himself to the higher phases of an advancing civilization if he is conscious of the gnawings of hunger. Since the shortage in various food products during the war, people generally have taken a much keener interest in the whole question of food supply. The old statement that "we never miss the water till the well runs dry" is here exemplified. So long as the grocer had plenty of flour and sugar most people considered the supply in much the same way as they considered the supply of air. The only worry was to find money with which to purchase needed articles.

When it became necessary to go to a dozen stores before being able to buy any sugar, and then only a pound or two; when the meat allowance was restricted; and when white flour had to be supplemented by all kinds of substitutes—then people began to realize that the supply of food might not be inexhaustible.

The shortage of food during the war has been a good lesson for the people of the United States. It has taught them what some of the peoples of Asia have been so often forced by famine to realize, namely, that food can be had only when a supply is available, and that this supply may at times be far short of actual needs. Conditions during the war were of course unusual; we hope they will never recur. I do not at this time desire to consider the food shortage due to the war but rather the whole food situation as it is likely to affect mankind in the future as the

[1] Address of the president of the American Society of Agronomy, Springfield, Mass., October 18, 1920.

population of the earth increases. There will be of course temporary local short-time food shortages due to unfavorable seasons, wars, or other unusual conditions. These situations will have to be met as best they can at the time. The thing to which I should like to direct attention at present is not this temporary condition of famine but rather the means by which people may be fed when the world becomes much more populous than it now is. Having an earth, the best land of which is already producing crops without any great surplus, how is it going to be possible for nations to grow, cities to be built, and civilization to advance? Is there a limit to the number of people for whom the earth can supply food, or can the increase go on indefinitely?

As a small boy I remember going through what seemed to me to be an immense forest with a man who said it contained enough timber to last the whole United States for a thousand years. In later years when I became old enough to make the calculation, I found that this particular body of timber would not furnish America's needs for a single year.

In the early days of the settlement of the west many who saw the large rivers made the statement that the water of these rivers could never be exhausted by irrigation. The supply was said to be limitless. Experience has shown that the water of many of these streams was exhausted before more than a fraction of the adjacent land could be served. Thus, all things have their limits. There is a limit to the number of people a given area of land can sustain, and since the area of land is practically constant there must be a limit to the number of people that can be fed. The number of course depends entirely on how fully the resources of the earth are utilized. It is possible greatly to increase production. I wish particularly to call attention to the methods by which the agronomist may assist in accomplishing this end.

I am not an alarmist. I do not wish to appear as one who is trying to stir people up unnecessarily. I should not even like to take the responsibility assumed by Sir William Crookes, who, in his presidential address before the British Association for the Advancement of Science in 1898, set a date when the shortage of food would begin to be felt. I do not believe that there is sufficient data available for any one to be so definite. A few facts, however, may be used to help in clarifying our minds on the subject.

It is well known that the population of all important countries of the world is gradually increasing. During the 110 years from 1800 to 1910 the population of the world increased from 640,000,000 to 1,600,000,000, or an increase of 152 per cent. Only a few generations ago there were vast continents of unsettled fertile land waiting to absorb the overflow from the populous parts of the world. There are still many large tracts of land that are not settled, but it is obvious to all who have made a study of the subject that the better lands are rapidly being put under cultivation, and only the more remote and more unfavorable areas remain. This does not say that there is not still available much excellent land, but let us consider the United States as an example.

In 1790 the population of the entire country was 3,929,214; by 1840 it had reached 17,059,453; while the 1920 census shows it to be more than 105,000,000. A century ago only the east coast was settled; the great heart of the agricultural land had not been touched. The rapidity of settlement of the middle northwest is indicated by the fact that between 1800 and 1820 the population of Ohio, Indiana, Illinois, Michigan, Wisconsin and Iowa was increased from 50,240 to 792,719, and by 1840 it had reached 2,967,840. Today the entire country has been thoroughly explored and the better land has been producing for nearly a generation.

In order to see just how our production and consumption have balanced during the last three score and ten years—the allotted time of man—let us examine the figures for wheat, probably our best index crop.

WHEAT PRODUCTION AND EXPORT IN UNITED STATES AVERAGE BY 10-YEAR PERIODS, 1849–1919

Decades	Bushels Produced per Year (Average)	Bushels Exported per Year	Per Cent. Exported
1849	100,486,000	7,535,901	7.5
59–68[1]	190,395,750	21,475,072	11.3
69–78	285,951,600	73,634,732	25.7
79–88	446,587,600	133,703,079	29.9
89–98	495,184,800	165,377,944	33.3
99–1908 ..	651,643,800	152,533,604	23.4
1909–18.....	754,471,400	172,400,807	22.8

In 1849 we produced approximately one hundred million bushels of wheat in the country, only 7.5 per cent. of which was exported. With the rapid settlement of the west production rose till during the decade 1879–1888 it reached 446,587,600 bushels, 33.3 per cent. of which was exported. Thus new productive land was brought under cultivation much faster proportionately than population increased. After this time, however, the population so gained on production that during the next decade only 23.4 per cent. of the wheat produced was exported, and during the ten years from 1909–1918 the exports averaged 22.8 per cent. of the production. This figure was much increased by extra exports during the war. During the years immediately preceding the war the exportation of wheat had almost ceased. In 1880, 80.4 per cent. of our exports consisted of agricultural products, where as in 1910 the percentage had dropped to 50.9.

These figures are significant since they show that, even in a country like the United States where the area and the resources seem to be almost limitless, it will not be long possible to continue to feed other than our own increasing population.

A condition that helps to bring this about is the rapidly increasing proportion of our city dwelling population. In 1820 only 4.93 per cent. were urban. In 1880 it had reached 29.5 per cent. leaving still 70.5 per cent. rural; ten years later 36.1 per cent. were urban and 63.9 per cent. rural; in 1900 only 40.5 per cent. were urban; and by 1910, 46.3 per cent. were urban and only 53.7 per cent. rural. Indications from the 1920 census are that this year will show more people living in cities than in the rural districts.

[2] Average of only 4 years.

With a condition of this kind the food situation is likely to become more acute than where most of the population live on the farm where they can more quickly influence the rate of food production. With the growth of many large cities and with the complex systems of modern transportation and exchange, the food question tends more and more to become a single whole-world problem rather than numerous small local problems affecting the smaller communities. With our modern systems unobstructed by war we shall probably never again have such devastating local famines as were so common in past generations in India, China, and Russia during years when there was an abundance in other parts of the world.

The situation as it appears to me is this: We live in a world with an increasing population. This increase can not expand indefinitely to fertile unoccupied lands since these lands are becoming scarce. The food supply must be increased as fast as the population increases, since food supply is the chief limiting factor in population growth.

There is no immediate cause for alarm, but it is the duty of scientists and statesmen to look to the future. We must not be content to be like Sam the negro who took his stove to his boss and offered it for sale for a fraction of its value. On being asked if he would not need it next winter he said he would but that winter was three months away while the circus was to-morrow.

Satisfying the needs of to-day is not sufficient: we must maintain a forward-looking attitude. It is impossible to make large increases in production quickly; years of preparation and work will be required to do anything of permanent value. An adequate solution of the world's food problem can be made only by deliberate planning. All factors involved must be considered and a world-wide program of work initiated, for the world is not a unit in production and in consumption.

The problem will involve a great variety of business and scientific interests. Credit, transportation, manufacturing and mechanics must all be called on to do their part. What we are now most interested in, however, is the contribution of the agronomist. What is his part in the world's food problem?

An examination of the question indicates that his part is a large one. While it is not entirely clear just what is included under the word "agronomy," the general understanding is that it has to do with anything affecting crop production, and since the food supply is in the last analysis a question of crop production, it would appear that the agronomist has a great responsibility in seeing that the people of the world do not want for something to eat.

Let us see what means he has available to meet this responsibility. We have already shown that the increasing population will call for increased production. This increase can be met in just two ways: First, by extending the producing area, and secondly, by increasing the acre-yield of the present cultivated area.

The method of enlarging the agricultural area will be discussed under the following four headings: (1) Increasing the irrigated area, (2) extending dry-farming, (3) drainage of wet lands, and (4) reclamation of alkali lands.

Of course there are uncultivated lands in the world that will not require any of the methods of reclamation mentioned above to make them productive. They may be inaccessible, or for some economic reason it may not pay to cultivate them even though they are fertile. In cases of this kind the agronomist has no particular responsibility. He is concerned primarily in solving the problems which call for his particular training in science. Since the better lands are already in use most of the increased area will be made available largely by cultivating the less favorable lands.

The methods by which we shall increase the yield on lands that are under cultivation will be discussed under the following three headings: (1) Increasing the fertility of the soil, (2) better tillage methods, and (3) the improvement of crops by breeding.

More than half the surface of the earth receives insufficient precipitation for the most favorable growth of crops. The best method of making up this deficiency is through the application of water by irrigation. Unfortunately, the supply of water for this purpose is so limited that only a fraction of the land can be served. In many cases hundreds of thousands of acres of fertile land are found adjacent to a stream that does not contain enough water for a tenth of the land. In a case of this kind it is obvious that the volume of water and not the land area is the factor limiting production.

Here the agronomist's problem lies in the direction of making the limited water produce as much as possible for each acre-foot. He must call in the engineer to help in storing the water of the flood season and making it available when it can be used by crops.

During the early days of irrigation no attempt at storage was made, but as the demand for water increased reservoirs were constructed, often at great cost. With the present structures, probably not more than half of the water in streams of the arid sections is fully used. The remainder runs to waste during the high water or is lost through inadequate systems. One of the first steps that may be taken to increase food production is the construction of additional storage reservoirs and the improvement of canals to eliminate seepage losses.

Even the water that is delivered to the land falls far short of reaching its maximum duty. Many questions affecting the water economy of crops must still be investigated and there must be a wider application of principles of scientific irrigation before the available water will produce maximum crops. The periods when crops are most sensitive to water applications, the varying needs of different crops, the best methods of applying water to each type of soil, and numerous other similar questions must be investigated by the agronomist and taken fully into account before the arid regions can develop to their full fruition.

It is difficult to give exact figures, but it seems probable that when all possible economies are put into operation the irrigated area of the United States can be enlarged to about four times the present area. It is largely through the agronomist, assisted by the irrigation engineer, that this enlargement can be brought about.

After all possible sources of irrigation water are fully utilized there will be many millions of acres of arid land that can not be served. The only possible chance for producing crops on this land is through the methods of dry-farming, which means that every process is directed toward moisture conservation.

Dry-farming is essentially a branch of agronomy. It is based on a system of tillage that will store in the soil the moisture of one or two years till it is needed by crops. Its success depends on the selection of crops that can endure the rigors of drouth and the breeding of special drouth-resistant varieties.

Probably a larger area can be added to the present productive land by the conquest of drouth than by any other means, but drouth is a relentless enemy of crop production and its successful conquest will call for all the ingenuity of students of soils and crops. Part of the preliminary work has already been done, so that one now sees grain fields where only sagebrush was found a few years ago; but there still remain many difficulties to be overcome before all these vast areas can be made to serve the needs of man.

In humid sections great tracts of land are covered with swamps and produce no important human food. When reclaimed these lands are often exceedingly fertile. The drainage of some of the larger swamps offers rather serious engineering difficulties, but these can in most cases be overcome. The drained swamp with its peaty residue calls for special methods of management and fertilizing, but since agronomists are seeking problems to solve they will not be discouraged by the difficulties encountered in changing a drained swamp into a fertile field.

Somewhat related to the drainage of the swamp comes the reclamation of alkali land since it is largely through drainage that alkali is overcome.

In all arid parts of the world the soil is likely to contain such an excess of soluble salts that crops can not be raised. This condition becomes more acute under irrigation. At the present time in the United States there are millions of acres of land that fail to produce good crops chiefly because they are impregnated with salts. In some of the western states alkali is considered to offer one of the most important and difficult problems affecting agriculture. It will be met by drainage, by special soil treatment, by breeding more resistant crops, and in other ways that agronomists may devise. The problem is now waiting; its solution will mean more food for the world.

Since 1840 when Liebig explained how crops feed great progress has been made in increasing the productivity of the soil. Before the rôle of mineral matter in the growth of plants was understood, all sorts of theories were advanced concerning the food used by plants and as a result many inconsistent practises of fertilizing the soil grew up.

When the real basis of plant nutrition was determined, the beginning of a rational use of fertilizers was at hand. This has resulted in increasing very materially the crop-yields of many soils.

Just how much the acre-yield can be increased is uncertain, but we are sure that by the proper use of fertilizers, by rotation and by better tillage methods the present cultivated area may be made to produce very much more than it is now producing, but the acre-yield can not be increased indefinitely.

Last year in his presidential address before this society, Dr. Lipman ably discussed the nitrogen problem in its relation to increased food production. Each element entering into commercial fertilizers might have been discussed by him with equal interest, so many are the problems surrounding the supplying of food to plants. Agronomists may be sure that they have not yet found out every method of increasing soil fertility by the use of fertilizers. As the needs for food become more pressing many additional discoveries will result from the researches of students of the soil.

Superior tillage methods, better rotations, and many other improvements in soil management may be expected to contribute to the increasing of the yield of the present cultivated area.

So much has been done during the last few generations to improve crops that we should hesitate before placing any limit on what may be accomplished in this respect in the future. The discovery of some of the fundamental principles of heredity has made progress much more rapid during the last few years than previously when everything was done by the hit-or-miss method.

If no additional land could be added to the cultivated area and if there were no way to increase the fertility of the soil, considerable relief in the food situation might in time be expected to come from crop improvement alone; but when this can be taken in connection with the others, it becomes an especially valuable tool. For example, there are almost unlimited possibilities in developing crops suited to resisting drouth, soil alkali, or other unfavorable conditions in which ordinary crops can not thrive. But here too there is a limit to possible improvements.

From the foregoing, it is evident that the agronomist will be able to render valuable service in insuring an adequate food supply for the increasing population of the world. The question now arises as to what his duty is in the matter. Should he sit idly by as a disinterested spectator and allow things to take their natural course, or should he assume initiative and take an active part in helping to forestall trouble? Will he be one who will give the ounce of prevention, or will he wait till the pound of cure is required? Probably both courses will be taken.

He who is progressive, he who takes his work seriously and is anxious to use his training for the welfare of his fellows, will doubtless take the more positive attitude and devote himself energetically to the solution of the many problems that crowd upon him. Only by profound research can these problems be solved; but he who devotes himself honestly to seeking these solutions will find joy unspeakable and will render a lasting service to mankind.

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SCIENTIFIC AND INDUSTRIAL RESEARCH IN FRANCE, ITALY, BELGIUM AND JAPAN

The British Committee of the Privy Council for Industrial and Scientific Research in their annual report to Parliament give some account of similar work in other countries. In addition to the activities of the French Department of Scientific, Industrial and Agricultural Research and Inventions, attached to the Ministry of Public Instruction, important steps towards building a great optical industry in France have been taken by the French Ministry of Public Instruction and Commerce, under whose auspices there has been created in Paris an establishment known as L'Institut d'Optique Théorique et Appliquée, with General Bourgeois as president. The institution will include a school of advanced optics, a research and testing laboratory, and a professional school. Measures have been taken to secure a government subvention and an appeal for funds has also been addressed to scientific and industrial organizations. Progress has also been made in engineering research in France. The metallurgical and engineering firms in Grenoble are showing a commendable exhibition of independent initiative and, without waiting for a more or less problematical government grant, have collected funds to found a mechanical and metallurgical laboratory. The laboratory itself is secured and they have appointed a competent local man as its head. There only remains the acquisition of the needful machinery and equipment. This is to be obtained partly by purchase and partly by gifts.