MEETING FUTURE WORLD WHEAT NEEDS

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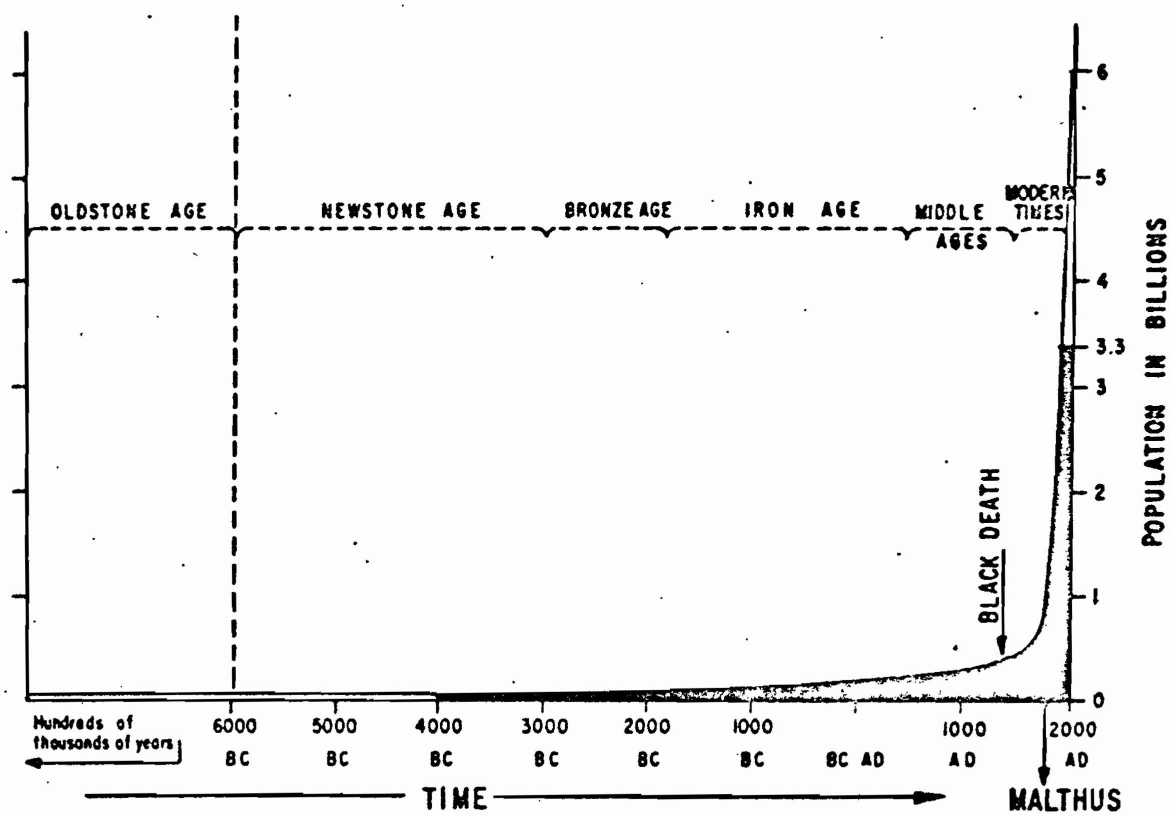
There is no industry that has made such marked improvements in efficiency as has agriculture in the last two or three decades. This dramatic progress and the development of surplus quantities of wheat and other grains in North America is not typical of the situation in most of the rest of the world even at the present time. Figure 1 gives a perspective of the world's population growth and shows that vastly increased food supplies will be needed on a worldwide basis in the next several decades.

Figure 1.

GROWTH OF HUMAN NUMBERS
(ANNABELLE DESMOND 1962)



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For many early thousands, and perhaps hundreds of thousands of years, survival was difficult and populations didn't increase very fast. It wasn't until hunting and fishing gave way to agriculture as a food source, about 5,000 years before the time of Christ, that things started to improve from the standpoint of stabilizing food production and population began to increase more rapidly.

There were probably 250,000,000 human inhabitants at the time of Christ, and then population began to increase rather rapidly. Population doubled by 1650. Significantly, it took 1,650 years to double that population. The next time it took only 200 years to double, and then it doubled again in only 80 years (Table 1.) From now until about 2000, the world population will continue to grow, and estimates are that there will then be about 6 billion people on this earth.

Table 1. World Population Growth

Period	Population	Year	Number of years for population to double
Adam and Eve	2	?	
			?
Early Christian	250 million	AD	
			1650
Renaissance	500 million	1650	
			200
Early Modern	1,000 million	1850	
			80
Modern Technological	2,000 million	1930	
(Present	3,346 million	1965)	54 ?
Future	4,000 million	1984 ?	

Two projections of population growth need to be considered. Some say that world population is now growing at about 2% per year, but there are parts of the world where it is growing at the rate of 3%. The more that people study this situation, and as statistics are taken more accurately, population growth rate estimates are raised to levels higher than suspected earlier. We always thought that Mexico had a growth rate of about 3.1% per year, one of the highest in Latin America. Just two weeks ago I saw a report, based on the last several years, which indicates that it's probably over 4%.

Table 2, based on 1963 levels of population and grain production, is a projection by decades of future cereal and wheat needs. In 1963 all cereal grain production in the world was about 996 million metric tons, of which wheat constituted 250 million. A 10-year projection at a 2% rate of population growth, assuming there is no shift between small grains and their relative importance, indicates that by 1973 a total of 1,214 million metric tons of all cereals will be needed. Needs will increase another 200 million tons by 1983, and up to 1,803,000,000 by 1993. Wheat needs alone, if projected, go from 250 to 452 million metric tons. In other words, wheat production will have to be essentially doubled by 1993. Grain required, if a 3% rate of population growth is assumed is, of course, substantially greater.

Table 2. Projection of Population Growth and World Cereal Grain Needs to Maintain Present Per Capita Consumption

	2% per annum increase			3% per annum increase		
		Grain needed (millions of metric tons)			Grain needed (millions of metric tons)	
Year	Population (millions)	All cereals	Wheat	Population (millions)	All cereals	Wheat
1963	3,216	996	250	3,216	996	250
1973	3,920	1,214	304	4,322	1,338	335
1983	4,779	1,479	371	5,808	1,798	451
1993	5,825	1,803	452	7,806	2,417	606

As far as wheat is concerned, by 1973 (Table 3) 54 million more metric tons must enter foreign trade if the rate of per capita consumption remains the same, and assuming that there will be only slight increases in production in countries that are now importing wheat. If you project the percent of the current international trade in wheat, the United States will have to increase its production by an additional 21.5 million metric tons; Canada, 13.6; Argentina, 5.6; Australia, 6.2; and France, 7.1. The supply problem becomes greater in future decades.

Table 3. Wheat Production in Millions of Metric Tons That Will Be Necessary if Present Major Exporting Countries Must Feed the Additional World Population (Assuming 2% Population Increase per Year)

Year	Projected World: Wheat Needs	Projected World: Additional Wheat Required	Additional amount to be furnished by: 1/ USA	Canada	Argentina	Australia	France	National wheat production must be: USA	Canada	Argentina	Australia	France
1963 2/	250 3/	-	-	-	-	-	-	31.1	19.7	8.1	8.9	10.2
1973	304	54	21.5	13.6	5.6	6.2	7.1	52.6	33.3	13.7	15.1	17.3
1983	371	121	48.2	30.5	12.6	13.8	15.9	79.3	50.2	20.7	22.7	26.1
1993	452	202	80.4	50.9	21.0	23.1	26.5	111.5	70.6	29.1	32.0	36.7

1/ Based on current percentage of international needs supplied by indicated countries.

2/ All projections based on 1963 production data.

3/ 42,180,000 tons moved in international trade in 1963.

It goes without saying that it is a physical impossibility to supply all world needs from the current exporting countries. Not only will there be problems in producing these larger quantities of grain, but there will also be problems in logistics (Table 4). Needless to say, there are going to be serious problems in the ports of embarkation and in the ports of discharge.

Table 4. Logistic Problem of International Wheat Movements

Grain Quantity: Bushels (1,000)	Grain Quantity: Metric tons (1,000)		Number of 10,000 ton cargos (ships)
37,000	1,000		100
185,000	5,000		500
1,119,000	30,000		3,000
1,998,000	54,000	(1973)	5,400
4,477,000	121,000	(1983)	12,100
7,474,000	202,000	(1993)	20,200

Those of us who are engaged in research need to examine our efforts in relation to the needs and the possibilities for vastly greater accomplishment. We've got to have vision. Gaines, despite the fact that it has quality defects, has opened our eyes to the potential for greatly increased per acre wheat yields. Wheat yields of 169 bushels per acre are a real breakthrough, and if we improve on the other aspects of Gaines, or wheats such as Gaines, then science will make a major contribution toward alleviating widespread world hunger, which clearly is just over the horizon.

What are the possibilities of increasing wheat and other cereal grain production in this hungry world? Many people say that it is very difficult to trigger off a revolution in agricultural production, and it is. However, in my opinion, if you concentrate efforts on several key production factors and understand how they fit together, the results are surprising. If, for example, you start spreading a little fertilizer on all the crops in a given country, dramatic and spectacular results will not occur, and no one is going to be impressed and stimulated. If, however, you know how to produce wheat under irrigation in countries, such as Pakistan or India, and if you can convince people at policy levels to concentrate their fire on one target, I think you can accomplish wonders by combining seed of the right variety, proper cultural practices, adequate fertilization, and sound water management practices.

Wheat yields in Pakistan can be doubled in five years! Dr. Ignacio Narvaez, my Mexican colleague now working in Pakistan, and I feel this can definitely be accomplished, with concentration of efforts and proper manipulation of all production factors. If yields can be doubled in Pakistan in 5 years, they can be doubled in India 2 years later. These are attainable and realistic goals, and those of us now working in Pakistan are committed to achieving them.

There are several important biological prospects for the improvement of wheat. One recent achievement has been development of semi-dwarf wheat varieties, such as Gaines or some of the Mexican varieties, which can utilize 2 or 3 times the amount of nitrogen used previously, and produce very large yield increases. Hybrid wheat varieties are certain to come. I am convinced hybrids will become economic under irrigation within a reasonable period. This will potentially add a yield increment of at least 20 percent above the yields of the best commercial varieties now available. There are problems involved in the development of useful hybrids, but none of these seem insurmountable.

Wheat quality cannot be sacrificed, and need not be, if producers are going to export and win a long-time place in world markets. I believe, as scientists, we can organize ourselves better on quality. Milling and baking qualities can be evaluated in segregating populations of wheat breeding programs in the same manner as many other important characteristics. It is necessary, of course, that suitable screening techniques be used to measure and to follow the desired genes in <u>early</u> stages of the breeding program. Satisfactory testing techniques have been effectively used in developing many Mexican and Argentine varieties.

What are the possibilities for making significant improvements in the nutritional quality of wheat? In the past, nutritional improvements have resulted from the enrichment of flours and bread with vitamins and minerals. I think we should make an effort through breeding to superimpose, on top of the quality characteristics that are now standard in wheat varieties, improved nutritional characteristics. All cereal grains, without exception, are especially deficient in the essential amino acid lysine. In the case of corn, a special gene, designated "opaque 2" has been found, which, if properly manipulated through breeding, is capable of increasing the lysine content of corn 2-1/2 fold. Significant differences were discovered in respect to the lysine content of wheat by workers at Washington State University. However, limited information with respect to wheat is confusing and inconsistent. Past methods and techniques of analysis have been inadequate, time consuming, and thus not usable in a wheat breeding program.

We are convinced of the importance of attempting to increase the nutritional content of major cereal grains through breeding, and the Rockefeller Foundation has recently made a grant of $700,000 for improving the nutritional value of cereal proteins. This will be done by breeding efforts involving corn, wheat, triticales, rice, and sorghums.

What about the percentage of protein? As grain yields go up, especially under irrigation, protein content goes down. In Mexico, through the widespread use of high yielding dwarf wheat varieties, we've added about 18 bushels to the average national yield of wheat in the last five years. However, we've lost an average of a percent and a half, or nearly 2%, in protein at the same time. Karl Finney at Kansas and others have successfully applied fertilizer at different times in an effort to compensate for the usual reduction in protein content as yields increase. It has also been found in recent years, in the case of Atlas 66, there is a gene that can be transferred to other wheats, which, even when yields are high, will produce grain with 2 to 2-1/2% more protein than other wheats of similar yield. We are working to increase protein percentage, because the biggest disaster that could possibly occur in a country such as Pakistan would be to have the yield of wheat doubled and yet lose 2% of protein in the process. People who get 80% of their calories from wheat with very little animal protein would probably be worse off in such a situation than they were before.

I am one of the firm believers that the contributions that Dr. Stakman and his co-workers at the University of Minnesota, other laboratories in Canada, and in other parts of the world, have made to rust control in wheat and other small grains, has been a landmark. These rust control programs have utilized specific genes for resistance against specific rust races, but there are an infinite number of races. There are some wheat varieties that have general types of resistance, sometimes called field resistance, or adult plant resistance, which I believe need to be utilized if we are to meet future grain production needs.

A similar situation exists in efforts to control late blight of potatoes. When scientists worked only with specific genes, there were constant changes in races and resulting losses from disease. However, since working with a combination of adult plant resistance, plus specific resistances superimposed on top of it, potato varieties have remained resistant to late blight in Mexico for at least 12 years. This has been done by Cervantes, Niederhauser and co-workers, and I think is a landmark in how to re-examine a scientific approach, develop a means to measure these different kinds of resistance, and then combine them in new varieties. If similar progress can be made in rust control of wheat, this would provide time for scientists to improve the protein quality and content, to improve milling and baking quality, and grain yields. With present rust control methods, it is a constant fight just to stay ahead of attacks from new rust races.

In this overpopulated world it is time that we all examine the potentialities for increased wheat production, improved rust control and better nutritional quality. Unless scientists take aggressive action in gearing wheat research to current and prospective world needs, we will fall far short of meeting human food needs. Hungry people, sooner or later, are going to become impatient. We have the technical know-how to feed much of the world in the years ahead, if we put our mind to the job, organize ourselves, and do it in a concentrated and practical way.