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"Plant Pathology and World Food Problems"

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Introduction

In my concept, this is a fitting moment in history to convene an international congress of phytopathology. Such a gathering emphasizes the international character of our discipline and demonstrates a general recognition that problems of plant protection are worldwide and of concern to all of society. Furthermore, the place chosen for these meetings and the backgrounds of the participants are clear indications of our awareness that education and research are universal, and of our desire to work with others in placing our experience and abilities at the service of mankind.

Man has sought constantly to improve the quality of life on this planet, and our craft can claim a constructive role in this effort over more than a century. From a material point of view, man has made incredible progress in conquering his environment and extracting from it substances which in their transformation have supported the evolution of modern technology in the service of society. Culturally, man has greatly enriched his life by advances in education and by the arts of music, literature, drama, painting, sculpture and architecture. It would, however, be irresponsible at this moment not to mention those areas of human experience in which our civilization has a record of repeated failures.

I refer, of course, to man's propensity to indulge in conflict with his kind. War in some guise is as ancient as human society itself and as a behavioral phenomenon in its highly mechanized and institutionalized form, it is peculiar to man and man alone. Wars have been fought on many provocations, including race, religion, escape from tyranny, ideological differences, naked lust for power and passing glory. In spite of all the terrible tragedies of destruction, loss of life and suffering, brought about by past wars and in spite of all its clearly visible threats to civilization in the future, we seem not yet to be convinced of the absolute necessity for universal respect for human life and intelligent, rather than violent, resolution of differences and issues. Not long ago, many believed that enduring peace would come when the instruments of war were made so horrifying that none would dare to use them. But we now know this to be a rude fallacy. We have such weapons, but we still have wars.

We do know that there are certain environmental factors which by themselves may not cause wars, yet which may exacerbate a conflict situation and thus may serve as war accelerators. These include hunger, poverty, disease, ignorance, disadvantage, deprivation, lack of opportunity and overpopulation. It is alarming to note that during the last twenty years, there have been 97 outbreaks of armed conflict and that the overwhelming majority occurred in areas where the per capita income was less than $300 a year. Peoples living in a state of chronic misery inevitably become more and more resentful of their condition as they recognize the wide and glaring differences between themselves and the more affluent members of society. As a consequence, they may grow impatient and become likely converts to any ideology which appears to offer them panaceas for a quick transformation to a better way of life. Frequently, this intensifies political instability and sets the scene for outbreaks of violence and conflicts of all kinds.

How much better it would be if mankind could sublimate what appears to be a human characteristic to wage war into a universal desire to attack the root causes of human disadvantage which together pose an ever-present threat that conflagrations may break out anywhere. This would involve an integrated approach to the problems of ill health and disease, malnutrition and hunger, poverty, ignorance, racism, crime and the other social ills of humanity. Such "wars" would be constructive and humanitarian and could contribute mightily to the possibility of peace in the foreseeable future.

We who are here gathered in conclave have dual responsibilities; first, those having to do with our roles as national and world citizens; second, those having to do with our roles as scientists and educators endeavoring to contribute to a particular body of knowledge and working to ensure that that knowledge is applied to useful purposes in behalf of mankind.

None of use can expect to escape our responsibilities with the excuse that as scientists we need not be concerned with the political, social and economic challenges which confront us. Not only is it our moral obligation as thinking men and women, living in a complex society, to do what we can for the welfare and security of all mankind, but our work, even our lives, as scientists depends on progress toward an atmosphere of peace and harmony. Although national statesmen and political leaders have failed to achieve a peaceful world, the scientific community, too, may perhaps have failed to recognize fully its responsibilities in a world of rapid change and precarious existence by reason of social and economic imbalance.

Specifically, the scientist's role as a scientist is twofold: first, to use his sophisticated education, training and experience to probe more deeply into his special discipline and in a variety of ways to help to assure that his knowledge and skills are applied broadly to the solution of the challenging problems which confront men everywhere; second, to work to insure that the forces unleashed by science are used for constructive purposes and that they never become the Frankenstein monsters of technology which destroy our environment, lower the quality of life, and create a growing spectrum of problems which all the powers of science cannot remedy.

With these two responsibilities in mind, it seems appropriate to discuss critical contemporary problems and the possible pathways to their solution. I think we might all agree that mankind's primary goals of peace and prosperity can only be built upon solid accomplishment--feeding those who are hungry, bringing health to those who are ill, and giving light to those who dwell in the darkness of ignorance. These are all difficult to achieve, but they are absolutely essential to progress toward highest humanitarian goals.

1. The Problems of Population Increase and World Hunger

In order to understand better our present situation, we must now turn our attention to population problems and make some "Observations Concerning the Increase of Mankind, and the Peopling of Countries." You will recall that this was the title of a paper prepared over 200 years ago (1751) by Benjamin Franklin to read before what is today the American Philosophical Society. Among his many and varied interests, Franklin included demography. In his paper he noted approvingly the high incidence in the American colonies of families of ten or more children and advocated that a high birth rate should be encouraged. He seemed intuitively to realize that the future industrial growth of the colonies would require a vastly increased skilled labor force, and therefore, unlike Malthus (1798) he had no fears concerning the ultimate effects of unlimited population increase. Dr. Franklin was obviously correct in his short-range projection, but was apparently unable to conceive of the future threat which would be attendant on uncontrolled population growth in the 20th century. When Franklin presented his paper, the world's population numbered approximately 728 million. Almost 50 years later, when Malthus first published his dire predictions concerning population, the world figure was approximately 906 million. Now in 1968, we have reached a figure of just under 3.5 billion and the numerical increase each day is estimated to be 160,000. Geometric progression of numbers is overtaking us, and at present rates there will be a world population of 6 billion by the year 2000.

There are those who publicly state their view that apathy, lack of understanding and negativism have already caused us to reach the point of no return. They observe that we are at present unable to satisfy even the minimum requirements of a satisfactory life for millions of people now living and that our progress toward eliminating hunger, malnutrition, ill health and ignorance is proceeding at a painfully slow pace. It is their opinion, therefore, that with current rates of population growth there can be no hope of achieving a balance between nutrition and numbers. They believe that disease and famine will continue unabated in many lands, and that population reduction will be accomplished only by decimation and other undesirable forms of human attrition.

A recent popular book predicts that there will be widespread famine by 1975. The authors are convinced that the more advanced nations will be obliged to apply the principles of "triage", used for medical cases on the battlefield, in their selection of nations to assist. Another writer gives us until 1985, and still another thinks that our day of reckoning will not come until the year 2000.

Because of the highly critical nature of the population problem, every effort must be made to communicate its urgency to all nations and their peoples, and every positive action must be taken to reduce birth rates through all reasonable and effective methods. Unlimited population increase will only compound all our other dilemmas and will militate against any future chance of our ever reaching a point where the curves of population growth and food production are in phase.

In my opinion, we do not need to accept the cause as lost, if we are willing to apply maximum intelligence and ingenuity to the population problem. Forces are at work and advances are being made toward population stabilization. Admittedly, the total effort is still small and the rate of progress is extremely slow. However, greater effort in research and its application in an atmosphere of improving communication and understanding can build up momentum.

Science must continue to provide improved methods for contraception. The IUD coil was the first and undoubtedly an important breakthrough, but it is a far cry from the more recently developed contraceptives. The pill was a second and notable advance which has been extremely useful, although it, too, is only one more step forward. Presently, there is growing evidence that an easily implanted steroid substance can provide protection from conception for long periods and that this could be readily reversed by removal of the implant. Nor is this advance, while welcome, the final answer. Ultimately, through further research in endocrinology, molecular biology, the physiology of reproduction, and immunology, it should be possible to develop new and simpler methods of regulating fertility over any desired period of time. When this can be accomplished by simple injection and without side effects, then we will have the means to make birth control possible on a worldwide scale. There are indications that social attitudes are changing and that they favor the acceptance of the theory and practice of fertility control. Moreover, in those countries where the state is being looked to more and more for the solution of complex social and economic problems, social security programs are making it unnecessary for parents to have many sons to care for them in their old age.

If there is evidence that birth rates can and will be reduced, vast effort to augment world food supplies will then become increasingly meaningful. Successful food production programs will do much more than contribute to the wellbeing of millions of the presently disadvantaged; they can also buy time during which population control programs can be mounted or expanded and extended. It is to this aspect of the problem that plant pathology can make its greatest contribution.

In retrospect, the progress of plant pathology and the results of its adaptive research have been phenomenal in accomplishment and astronomical in both the quantitative and qualitative benefits which have accrued from them. Beginning a century and a half ago and evolving gradually from the work of many scientists of diverse disciplines, plant pathology today is a highly developed and sophisticated science. Its practitioners have added massively to our knowledge through fundamental research, but have never forgotten their social mandate to increase the world's supplies of food, feed and fibre for the benefit of mankind.

We here tonight must give much of the credit for modern scientific advances to the enterprise and imagination of those of our profession and others who have preceded us. Working without the highly sophisticated instrumentation now available and often depending solely on intuition and observation, each individual contributed significantly to our understanding of the plant and its environment, including the hostile components. As understanding grew and the body of basic knowledge increased, the observations and experiments began to take on greater meaning and contributed to our present comprehension of biologic and related phenomena.

It is, of course, impossible to mention all of our distinguished predecessors who did so much to create the science of plant pathology and to bring it to the high position which it presently enjoys within the scientific community. However, it is interesting to read their views and ideas and from them to trace the evolution of phytopathology. Among those who have greatly influenced the study of the biology of parasitism come to mind at once such figures as: Fontana, Tillet, Targioni-Tozzetti, Prévost, Millardet, de Bary, Sorauer, Brefeld, H. Marshall Ward, Burrill, E. F. Smith and L. R. Jones.

It was a fortunate circumstance that at the same time our knowledge of the world around us was increasing, the economic development of the more industrialized nations permitted the several scientific disciplines the luxury of greater specialization. This enabled each to develop critical mass and encouraged its investigators to probe deeper and deeper into the cosmos of science in their attempts to find exact answers to specific problems. Thus, a highly advanced science and technology made it possible to attack selected problems with all the skills and instrumentation available. As solutions were found, these in turn opened up new avenues for study. In the science of food production, the net result has been that the more advanced nations today enjoy a highly nutritive diet of variety foods from both temperate and tropical climates, available 365 days a year at prices within the means of the majority of the population.

For a variety of reasons, not all the agricultural areas of the world have been benefitted by modern agricultural science. In the case of the less developed areas, most of which are primarily agrarian, agricultural productivity is lagging far behind potential and as a result they are in a perpetual state of underproduction. Millions of adults are chronically undernourished, but what is even more serious, the vigor and productivity of the adults of the future are being impaired because of prevalent infant and juvenile malnutrition which can cause irreparable damage to the central nervous system of children. Many of these countries are as yet unable to satisfy their own basic and minimal food needs and at the same time are unable to generate sufficient foreign exchange to purchase their requirements on the world market.

Many of the less developed countries could double, treble or even quadruple present yields of food grains simply by taking advantage of currently available technology, supported by economic inputs and accelerators. Highly efficient varieties of rice, wheat, corn, sorghum, millets and other crops are now available. Properly managed, with suitable seed bed preparation, adequate water, the necessary fertilizers and other agricultural chemicals, these new varieties can insure greatly increased yields.

Over twenty years ago, Mexico determined to close the then existing food gap which was forcing that country to invest substantial quantities of foreign exchange in the purchase of basic food grains, principally corn and wheat, from abroad. With some foreign assistance, a sustained program of adaptive research was undertaken. The widespread application of this research enabled Mexico to satisfy its basic food grain requirements by the mid-1950's in spite of the fact that during that period Mexico's population was increasing at the rate of 3.6 per cent a year. Since then, the pattern of successful production in Mexico has been applied to India, Pakistan and other countries, with dramatic results in terms of increased yields. In the meantime, an International Rice Research Institute was established in the Philippines and has provided improved varieties and methods which each year are adding substantially to the world's total rice production, especially in those areas where rice is the staple food but in short supply.

These successes are evidence of what can be done to close the present world food gap. They demonstrate the enormous possibilities which exist for greatly increasing food supplies in many parts of the world through modern techniques applied to conventional agriculture. They prove to all who will look and understand that there need not be famine and hunger if the agricultural industry is properly organized, activated and supported. Although it is perhaps unnecessary, we might also remind ourselves that without the intensive intervention of plant pathologists as well as other scientists in this international effort, the present recorded successes would have been impossible.

In theory, the process of overcoming underproduction may appear to be simple; in practice, it is often extremely difficult. The first and foremost consideration is to change attitudes. The traditional concept of agriculture must be transformed into one that regards agriculture as a modern industry. Science alone cannot bring about this transformation, but, given the opportunity, the scientist can clearly demonstrate in concrete fashion the benefits of treating agriculture as a business, as an industrial enterprise with a strong profit motive. Today, subsistence agriculture is not good enough. We must maximize the rational exploitation of our soils and related natural resources in the service of mankind. Otherwise increasing population pressures will cause a widening of the food gap, with all the attendant social ills which could threaten our very survival as a civilization.

There are presently a variety of technical assistance programs in progress under the auspices of governmental, international, private and philanthropic agencies. Although each has played its own constructive role and all have accomplishments to their credit, the past record would have been far better if prior agreements had been made concerning priorities and procedures for at least informal interaction and cooperation toward a common cause, which in this case is sound agricultural improvement. The record of the future can be better, and this vast and difficult task can be accomplished in an orderly fashion through analysis of the problems, the establishment of priorities, careful planning and direct attack. The approach must be harmonic and the several programs fully orchestrated, requiring the full mobilization of science and technology, strong political support, and national and international investment. In this way, considerable progress can be made immediately and long-range plans can be drawn up to assure continuing annual gains in the future. In the area of food production, improved biological materials, seed increase and distribution programs, appropriate quantities of fertilizers and other agricultural chemicals, and an attractive investment climate are all essential to assure that the agricultural industry will prosper. Storage, transport and market facilities must also be available as needed. These, along with farmer incentives such as loans, subsidies and price supports, can result in rapid and dramatic increase in production figures with attendant social and economic benefits.

In the international effort to increase food supplies, the industrialized countries must keep their own scientific sights high if they are to continue to provide themselves and others with essential agricultural commodities, especially the foodstuffs needed for growing populations. The less-developed nations will have to embark on enormously expanded agricultural production programs for which the materials and methods are now available. And we are especially going to have to push agriculture deeper and deeper into the tropics where the potential is enormous but where actual production figures are far below the possibilities. Much of our success will depend on the speed with which it is possible to mobilize the technology, acquire the prime ingredients, and provide the economic accelerators and incentives essential to a steady improvement in production.

The threats are imminent; the problems are vast, but not insurmountable. Understanding among concerned scientists, economists, sociologists, political leaders, business and industry can make the difference in assuring both adequate world food supplies and progress toward population stabilization. However, each discipline while interacting with others must also develop new thrusts and innovations to make these efforts even more effective.

Many of the remarkable successes which can make up the history of modern agriculture owe much to the science of phytopathology. Our predecessors and others, early recognizing the devastating effects of epidemic diseases, worked unceasingly to understand the principles of phytopathology and to find ways to protect or defend crop plants against the inroads o f disease. As in other problem areas there have been sucsesses and failures, but the former far outnumber the latter. Today, we have plentiful quantities of high-quality foodstuffs, partly because they are carefully protected against disease in the field, during transport, in storage and at the market place. In each phase the plant pathologist plays a critical role. And as new knowledge emanates from our laboratories and experiment stations it is sped to the farmer to assure that we continue to meet the challenge posed to our economy by plant pathogens, These successes must be multiplied many times in many lands if we are to feed all the people and buy time for population control programs to develop impact.

For many years the main thrust of the science of plant pathology was upon defense against disease. The widespread use of dips, soaks, sprays, dusts and soil disinfectants were testimonials to the defense theory of plant protection. Plant selection and simple breeding techniques later joined protective chemicals in the battle against plant disease. Little by little our knowledge broadened and deepened through research and its adaptation. In retrospect, we can look back on these achievements of phytopathology and find them good. Through basic and applied research we have gone far toward assuring that the epidemic outbreaks of the past will not recur in similar number and dimension in the future. We can now hope that the tragedies of the chestnut blight, the potato famine and the great epidemics of cereal rusts will not have their counterparts in the future. We are moving more closely to an understanding of the whole plant, its physiology and its reaction to its environment. Our chemical protectants have become more sophisticated, and include not only external treatments but systemic and antibiotic compounds. We are becoming more expert in genetic manipulation and have learned to work with chemists, physicists and engineers in seeking to find anwers to intricate problems.

In plant pathology, as in other sciences, we must avoid tunnel vision. Specialization needs no defense until it becomes overspecialization at the expense of economic progress. I can not think of the phytopathologist as simply a plant doctor ministering to the ills of economic plants. Rather I think of him as a biologist, probing ever more deeply into the mysteries of plant behavior and translating his research into meaningful knowledge and action in behalf of mankind.

II. Future Trends in Plant Pathology

It is perhaps appropriate tonight to contemplate some of the possible future trends of phytopathological research, geared to meeting the increasing demands for food throughout the world. The following, I think, are a few indications for the future.

Biological control of plant pathogens, with the possible exception of nematodes, has in the past apparently been considered an unproductive research exercise, although there have been a number of significant successes in the biological control of insects, rodents and certain "weed" plants. Admittedly, in the field of plant pathology, evidence of possibilities for biological control is sparce, but there may well be significant opportunities to identify biological enemies among pathogens and to turn this knowledge to good use in plant protection. There are a few interesting reports of parasitism of fungi by other fungi and quite possibly this area merits greater attention. It may be that certain viruses can be utilized to suppress others within plant tissues. Bacteriophages are conceivable useful tools in intracellular plant virus control. It would appear worthwhile to consider all possibilities and to press those which seem most promising.

We still have much to learn about the intricacies of plant behavior, and it behooves the pathologist to strive continually to gain greater understanding of the full range of plant function from the whole plant to its fine structures. Fortunately, there are now at hand, and growing apace, an extraordinarily sophisticated array of instruments with such flexibility as to make their use appropriate to the broad spectrum of science. The utilization of these devices in an integrated fashion provides a powerful and ever more precise tool for the phytopathologist attempting to innovate in the field of plant protection. Instruments cannot substitute for observation and critical judgment, but they do extend the capabilities of the biologist in the study of cell, tissue and whole plant physiology. It is now possible to follow a variety of translocations and chemical pathways within the plant, to identify the roles of micro- and macronutrients, and to assess the possibility of introducing elements or compounds which may alter physiological patterns in ways which might effect the biological balance between the plant cells and pathogens. A wide range of analytic equipment, tracer complexes, high resolution microscopes and other modern instruments has now been backed up by the computer. Together, these offer insights into plant behavior never before possible and can be expected to open new approaches to plant disease control.

Genetic manipulation of plant species is as old as plant breeding, but its modern aspects offer exciting new possibilities for disease control as well as for greater productivity. It is becoming increasingly possible to map and identify the genes controlling a variety of functions and to introduce or extract genetic factors for a variety of traits, including disease resistance, increased yields, tolerance to heat, cold and drought, photoperiod insensitivity and increased amino acid content of food products. Currently, efforts are also being made to collect, identify and store genes. Scientists can then draw on these "germ plasm banks" as they are needed.

One highly interesting form of biological engineering is the new IR-8 rice variety which has been remarkably successful in most rice-producing regions. The phenotype differs strikingly in appearance from the varieties previously grown in the areas where it has been introduced. IR-8 has been developed as a stiff, short-strawed, dwarf type to restrict lodging, the foliage is concentrated at the top of the plant to maximize photosynthesis; and the panicles lie below these top leaves. The variety is insensitive to photoperiod, so its use is not limited by latitude. It is highly productive and outyields the standard varieties 2- to 5-fold. Grain quality is high and efforts are being made to identify and build into IR-8 and related varieties an increased capacity for the production of lysine and other critically important amino acids. This is an example of one of the most direct types of biological engineering where the scientist may for certain desired ends alter plant types and exert increasing control over their functions.

Nevertheless, we still have a long way to go in designing plants for the future with higher productive and nutrient efficiencies. We do not yet understand nitrogen fixation, and it may be that this phenomenon is transferable to cereal or other crops. It might also be possible to increase very significantly the protein fractions in plant products, with commensurate benefits to those who for one reason or another are limited to a vegetarian diet. This matter of food quality is vital to the future of human nutrition, and we must struggle not only to avert hunger but to provide balanced diets for all peoples. In order to progress on these fronts we should be able to take increasing advantage of mutagenic chemicals, hormones, x-rays and lasers. The possibilities of induced polyploidy are by no means exhausted, and we can undoubtedly make wide crosses far beyond those now considered possible. We must study the possibility of transduction as a pathway for resistance and must learn how to get at the basic genetic apparatus of the cell DNA for induced genetic re-arrangement for plant improvement. Plant pathology must increasingly draw upon biochemistry, and cellular and molecular biology, which also surely hold critical clues to the future.

If we are sufficiently imaginative and creative, we may be able to design plant types for maximum efficiency and to biologically engineer them to our specifications. Using all the tools and techniques at our command, we can analyze ecological factors and relate them to plant design. We shall definitely have to move away from the conventional and look for non-conventional opportunities. These may include tissue-culture techniques leading to single-cell selection as a source of elite plant types. One day, too, we may learn to produce somatic hybrids which will open up whole new dimensions of plant science. All of these suggestions are but a few of the possibilities for the future. As biologists, we should be aware that all these pathways are open to our investigations. As phytopathologists, we should also realize that they can serve to expand and extend our contributions to a world increasingly in need of our contributions in collaboration with other scientists.

Given the vagaries of nature and the fact that the practice of agriculture is in contravention of the biological balance which nature establishes if unimpeded, it is evident that pests and pathogens will continue to threaten the agricultural industry. This requires that the plant pathologist become increasingly knowledgeable, imaginative and effective in his efforts to prevent and combat the biologic enemies of the crops upon which mankind depends. The reports and exchanges which take place in congresses such as the one in which are now engaged can measurably advance this cause.

In conclusion, I view the future with cautious opimism. I believe that even though belated, there is a growing awareness of the fundamental problems which hamper our efforts to improve the quality of human existence everywhere. The food problem is at present the subject of worldwide concern and is the object of a great many assistance programs which in toto are still woefully inadequate. The population question is now being freely discussed and debated, and positive action, although on a small scale, is being taken. These are hopeful signs, and if the several components of the society can interact in efforts to solve these and other social ills, then the future can be better.

As we move toward improvements in social organization and performance, we, as scientists and citizens, must keep in mind the new threat which is on our horizon. This is the alarming fashion in which scientific and social advances are changing the quality of our environment. This menace has many facets. It is not limited to the developed countries, but in various forms affects all nations. Included are the destruction of our soils and water courses, negative interference with the food cycle and positive pollution of our air envelope. Contributory factors are the wanton exploitation of our renewable and non-renewable natural resources, improper disposition of human and industrial wastes, the outpouring into our atmosphere of billions of cubic feet of fumes, smoke and other impurities. Added to these are all the other ills which accompany social evolution in a period of rapidly increasing population, technological advance and urbanization, with all the demands which these make on our total resources and long-range planning abilities. Agriculture, too, complicates the ecological pattern, and we must be ever alert to assure that, as we bring about progressive changes in all areas of biology and agriculture, these do not contribute toward making environmental conditions worse rather than toward improving the quality of the human condition.