ROLE OF AGRICULTURAL RESEARCH IN CONQUEST OF HUNGER

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IT appears to be an appropriate time to pause and reflect on the contributions that have been made by research and the application of its findings toward increasing agricultural production for the improvement of the well-being of the entire Indian population. It is also a time to glance toward the future and focus on many still unsolved problems. India must agressively continue to expand its scientific knowledge so as to facilitate and expedite increasing food and fiber production. This is essential in order to meet food demands of the present population of more than 620 million, and, in addition, to provide for the increase in demands for the future, resulting from an increase of 12 to 13 million more people each year. This is no small task, and there is no time to relax and no room for complacency if the challenge is to be met.

Most people fail to realize that there can be no long delay in meeting the growing demand for food. If the world failed to meet the increase in demand for food production caused by annual population growth over two or at the most three crop years, the results would be disastrous. As the grain reserves or buffer stocks, were depleted prices would soar and many food deficit nations would be plunged into famine and as a consequence into social and political chaos. Nevertheless, in the urban areas of the industrialized nations—as well as in the cities of the developing nations—food is all too often taken for granted by most of these non-rural populations. Most urbanities everywhere, and those of the U.S.A. in particular, seem to believe that food comes from the super-markets, and that it is easily produced and should always be cheap. They seem to have virtually no concept of the magnitude of the food production needs nor of the capital investments, managerial skills, hard work and risks—of adverse weather, of crop losses caused by diseases or pests or of unpredictable economic variables—that are involved in producing the food for the present world population of 4.2 billion people.

During the past decade the situation has been further confused by doom-sayers and extremist in the environmentalist movement. They insist that we are being poisoned and our health is being impaired by chemicals,

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despite statistics and evidence that indicate that we live a longer and healthier life than ever before. *Homo sapiens*, as a species, is so constituted that some individuals keep searching for the fountain of perpetual youth. I'm convinced it will never be found. There is a growing body of evidence that there is probably a biologic time-clock at the cellular—or more likely chromosome level—that controls senility. I, too, believe that we should search for ways to solve health problems so as to extend life for as long as it remains pleasant and enjoyable. But I see little point in perpetuating it beyond such a point and thereby foster intolerable suffering and misery. Moreover, were it possible to achieve a "life-style of perpetual youth", I personally believe, it would be disastrous to civilization. Civilization would be overwhelmed by the population monster on many fronts e.g. by shortages of food and fiber, water, energy, many non-renewable mineral resources, and from environmental pollution. Before civilization collapsed because of human population pressure it would dispatch into extinction many 10's of thousands of species of animals, birds and plants. Is this the goal we are striving to achieve ? Is this the destiny of world civilization ?

ICAR can be justly proud of its accomplishments over the past 50 years. Five decades is a relatively short time frame for developing and implementing agricultural and rural development programs, just as it also is with industrial development. Nevertheless, I doubt that more than a small percentage of the political leaders and bureaucrats, industrial leaders and merchants have much appreciation of either the obstacles that have been surmounted, or of the magnitude of progress that has been achieved in revolutionizing Indian agricultural production, which in the past two years has finally resulted in achieving self-sufficiency in grain production. This lack of comprehension stems from a failure to understand the complexities of agricultural production, and in the broader context rural development; few comprehend the long gestation period involved between the launching of a research program until the information and materials which it generates, can be applied on a sufficiently large land area to transform a stagnant traditional agriculture into a high yield progressive agriculture, capable of alleviating hunger and human misery. To be successful, it must involve developing a package of improved technology capable of increasing yield per acre on farms by 50% or more over that of traditional methods. The improved technology, derived from sound research, must consist of the development and use of well adapted high yielding crop varieties, combined with improved cultural practices, including the use of the right kind and amounts of fertilizer to correct soil infertility, efficient utilization of moisture and control of weeds and other pests.

The package of improved technology after being demonstrated to be effective on hundreds or thousands of farms must be linked to government economic policy that will stimulate adoption of the new technology by farmers. This must include the availability of essential inputs such as seed

of improved varieties, fertilizers, credit to finance purchase of the inputs and assurance of fair price for grain at time of harvest.

It is my contention that we, agricultural scientists, must bear the major responsibility for failing to effectively inform the political leaders, the communications media—press, radio and television, educators and the non-rural populations in general, and especially in the affluent developed countries, about the important role that agriculture plays in social and political stability and in human progress. Peace and human progress is not built on hunger and empty stomachs. Food is, too often, taken for granted by most affluent influential groups and so are farmers, ranchers and fishermen. The idea seems to be widespread that it takes little skill and talent to a successful farmer. The situation has been made worse over the past decade by the articulate doom-sayers in the environmentalist—neo-ecological movement who have been heard and believed by many influential political leaders, and the popular press and privileged citizens, who have never known either hunger or famine. Unless the voice of agriculture is heard soon and unless many of the restrictive bureaucratic rules and regulations are modified the war against hunger will be lost because of our own inarticulateness and ineptness. Who then will assume the responsibility for the disaster ?. I doubt it will be those agricultural scientists who today are mute and not making their views known in many of these important controversial issues.

THE HISTORY OF AMERICAN AGRICULTURE

In order to bring better perspective and more merited appreciation for the great progress and achievements that I have been privileged to see in the improvement of Indian agriculture over the past 15 years, let us first glance at the history of the development of American (U.S.A.) agricultural production, which is today, in many countries of the world, held up as a model of productivity and efficiency. At the outset, let us not forget that American agriculture did not achieve its current high per hectare yields neither easily nor rapidly ; nor was its development handicapped by heavy population pressure.

The increase in American agricultural production in the first more than 300 years—from the early Colonial period up until post-World War II—was for the most part, achieved by following the traditional pattern of other countries, namely, by increasing the area under cultivation as the markets for more food and fiber justified. Good land during this period was abundant and relatively cheap. During the period from about 1830 until 1930, the greatest stimulus toward increasing production was through the development and widespread adoption of improved farm machinery, which up until the first decade of the twentieth century was horse powered but subsequently increasingly more steam and petroleum powered. Improvements in farm machinery contributed to increase production in two ways : it increased the land areas that could be cultivated by a family and

(2) it modestly increased yield per cultivated acre, largely as the result of better seed bed preparation, which in turn also resulted in better conservation and utilization of moisture and better weed control. But the revolution in yield per cultivated acre did not happen overnight. In fact it had a gestation period of approximately 65–75 years. The foundation for this change was laid in 1862 when President Lincoln, within a period of a few weeks. signed into law three important bills that : (1) established the Land Grant Colleges to educate and train men and women in the skills of agriculture and mechanical arts ; these agricultural colleges subsequently developed into great universities ; (2) established a Bureau of Agriculture, which was subsequently to evolve into the United States Department of Agriculture, and (3) established the Homestead Act, which provided land to the landless immigrants and other Americans who had interest in becoming farmers. Each of these laws subsequently contributed greatly to the improvement of agriculture.

Reading between the lines in the history covering the establishment and early decades of the Land Grant Colleges (Agricultural Colleges), however, one finds considerable unhappiness among farmers with the quality of the training and education being provided. The common complaint was that the professors were too theoretical, and knew very little about practical farming—"they did'nt even know how to plow". More than two decades after the agricultural colleges were established, there was little evidence that they had produced much positive impact on agricultural production. Probably in a large part to correct this weakness, the Hatch Act was passed in 1884, which established the Agricultural Experiment Stations in conjuction with and to strengthen the research efforts of the Land Grant Colleges. In 1914 the final key organization of the triumverate—(education, research and extension)—the Federal Extension Service was established and charged with the responsibility of extending the new technologies to farmers and ranchers, as they became available from research done at the agricultural colleges and experiment stations.

Even after these improvements in the system, functional useful technology did not spew forth from the colleges and experiment stations in the early decades—perhaps largely because of a shortage of well trained experienced scientists—the same handicap that currently slows agricultural development in most third world nations.

In the last four decades of the nineteenth century early American investigators drew heavily upon the research experience and leadership in soil fertility and crop rotations that had been developed by Leibig in Germany, Laws and Gilbert in England and Bassingault in France. Similarly, the pioneer work of Pasteur, Dubaery, Koch, etc., etc., in microbiology, strongly influenced and guided the early American research in plant pathology, entomology and veterinary medicine. The truth is research information that was immediately useful for solving agricultural problems on farms and ranches developed slowly. Gradually over three decades,

beginning with the last decade of the nineteenth century and especially during the first two decades of the twentieth century progress accelerated. During this period many of the individual pieces of the American yield production jig-saw puzzle had been worked out by researchers in the fields of soil science, agronomy, plant breeding, plant pathology, entomology, animal breeding and nutrition and veterinary medicine. Unfortunately, however, largely because of a stroke of bad luck in timing, most of this potentially valuable technology lay dormant and unused for 15 years because of a stagnant sick economy. Unemployment and overproduction of both agricultural and industrial goods plunged the nation into the economic depression of the late 1920's and 1930's. Then, quickly, in the late 1930's, under the economic stimulus of demand for more food to support the European, African and Asian allies during World War II, and immediately following the war, when the agriculture of these countries was in disarray, the economic parts of the American agricultural production jig-saw puzzle fell into place. The technology that had laid largely unused for more than a decade because of the economic crisis, began to be applied and production within 3 or 4 years increased substantially. The most spectacular increase in yields per acre, however, did not take place until the 1950's and 1960's. During that period the rapid increase in the production and availability of inputs, such as fertilizers, weedkillers, fungicides, insecticides occurred and catapulated both yields and production. The private sector played a major role in the development, introduction, manufacture and distribution of these inputs, as well as in the development of better equipment for use in their application. These events gave rise to the greatest revolution in crop production the world has ever seen. Yields per acre within a few years, rose spectacularily. In the span of 35 years—from 1938–40 to 1971–73, with further improvements in technology, yields expressed in bushels per acre rose spectacularily as follows : maize 28.4 to 92.2, wheat 14.2 to 32.8, soybeans 19.2 to 27.7, sorghum 13.0 to 57.7, barley 23.0 to 43.2, cotton 0.5 to 1.0 (bale), beans 8.9 to 12.4 (100 lbs), potatoes 75.0 to 231.0 (100 lbs) and peanuts 7.5 to 21.9 (100 lbs).

For the first time in the history of American agriculture it had become possible to produce vastly greater quantities of food, feed and fiber on much less land. For example the quantities of food and fiber harvested in 1971–73 employing the new improved technology would have required more than twice the land area to produce the same quantities had 1935–40 technology been employed.

It should be pointed out, however, that it took nearly 75 years, from 1864 when the educational and research programs were launched, until 1940 when all the factors—biologic, agronomic and economic—essential for triggering a rapid change came together harmoniously and catalized the rapid aforementioned spectacular widespread adoption in technology and the large increase in yield per acre. Although yields per acre of these same

crops in the U.S.A. have continued to increase during the past decade, it is at a much slower rate than during the 1950's and 1960's. This trend is likely to continue for it will become more and more difficult to obtain further increases as the maximum biologic yield limits are approached. This also implies the United States, which is today, the largest exporter of food into international markets, can not continue to expand its volume of food exports indefinitely at the same rate it has achieved during the last three decades. This also infers that during the next two to three decades the yield per acre of basic food crops in most of the food deficit developing nations must be increased dramatically if hunger, famine and human misery are to be averted. It will become increasingly more risky for food deficit developing nations to rely heavily on imports of basic foods.

Fortunately, ICAR and other collaborating agencies, with the enthusiastic participation of Indian farmers, during the past two decades have shown the world what can be done to cope with this problem in the medium term time frame. These results show : when agriculture is given a high priority in development programs by government, when appropriate research and good reliable technology is developed by a team of enthusiastic inter-disciplinary scientists and when the improved technology is widely demonstrated on farms and adopted by millions of farmers who were provided the opportunity and encouraged to participate by the employment of stimulatory economic policies by government a so-called green revolution was triggered which rapidly changed a traditional agriculture into a progressive productive agriculture and in the process greatly increased food production.

FIFTY YEARS OF SERVICE AND PROGRESS

During its 50 years of existence ICAR has played a key role in the improvement of Indian agricultural education, research and its application to increase production. During its evolution and especially during its first two decades of existence as the "Imperial" (Indian) Council of Agricultural Research, much of its training and research effort was directed toward increased production and improvement of export crops. Nevertheless, it was also during this period that many outstanding young Indian scientists were identified and sent abroad for scientific training. After independence, these well trained scientists assumed the leadership roles of the Indian Council of Agricultural Research and other organizations. They in turn increased the number of more trained scientists and as their services became available, soon greatly expanded research activities to include most of the economically important crops and animals. The full impact of the preparation and utilization of scientific talent to solve agricultural production problems has quietly made itself apparent during the last decade by revolutionizing wheat and rice production.

My first contact with ICAR goes back to a brief visit made to India,

as a member of a United Nations Food and Agriculture Organization (FAO) wheat team in early 1961. Beginning in 1962, however, and continuing up to the present I have been privileged to have established and maintained both personal and organizational contact with IARI and its scientific staff (as well as with scientists from provincial universities and institutes) through both my Rockefeller Foundation and International Center for Maize and Wheat Improvement (CIMMYT) affiliations.

Although I have spent 35 fascinating and stimulating years of my scientific career attempting to assist many developing nations to improve their agriculture, I can truthfully and without exaggeration say, none of these many other experiences can compare with the delight and satisfaction I have enjoyed from seeing the revolution in cereal grain production, and especially that of wheat, that has occurred in India over the past 12 years. The rapidity and magnitude of increase in wheat production, from an average of 11 million metric tons over the 8 year base period 1959–1966 to 16.5, 20.1, 24.1, and 34.7 million metric tons for the 1968, 1970, 1975 and 1979 harvests respectively, is unmatched anywhere in the world. It is a feat that more than matches the increases in crop yields in the U.S.A. during the 1950's and 1960's. During the short period of 12 years, production has more than tripled and per acre yields have nearly doubled—truly a wheat revolution.

The Indian revolution in cereal production was not, however, confined to wheat. Rice production in a similar way increased from an average of 30.5 million metric tons for the 1965–67 period to 37.6, 40.4, 48.7 and 53.8 for the 1967–68, 1969–70, 1975–76 and 1978–79 crop years, respectively.

The spectacular increase in wheat and rice production combined with more modest increase in production of other grains resulted in India becoming self-sufficient in cereal production for the first time in 1977. Moreover, it enabled the country to build up, from domestic production, a buffer reserve stock of grain which now stands at more than 22 million metric tons from the excellent rice and wheat harvests of 1978 and the record wheat crop of 1979. Total food grain production for 1978 and the record wheat crop of 1979 is provisionally estimated to have passed 130 million metric tons for the first time.

Since I arrived here two days ago I have read in the press and heard various reports concerning the failure of the current monsoon and the widespread drought—reputed to be the worst in 40 years—that threatens to greatly reduce the forthcoming rice harvest. Now, however, in contrast to the pessimism during the 1965–66 drought, I sense among most government officials and scientists a new confidence. Under present circumstances it is gratifying and reassuring to have in storage the 22 million ton buffer stock of wheat and rice which will, I, too, believe, provide adequate protection against a poor rice harvest. Prior to the development of the so-called green revolution which made possible the accumulation of this

large buffer stock, a drought of the present magnitude would have resulted in misery, hunger and famine for 10s of millions of Indians.

The aforementioned revolution in Indian agricultural production has been achieved under conditions that were in many ways much more difficult to achieve than those which led to the spectacular increase in yield and production in the U.S.A. in the 1940–1970 period. That revolution in yield had a gestation period of 65–75 years, after the research base was established. Indian's progress was, moreover, achieved despite the handicap of a high level of illiteracy among the rural farm population, whereas the U.S.A. did not need to cope with this problem. Heavy population pressure on the arable land base which had resulted in fragmentation of ownership into millions of 2 to 5 acre holdings, as well as many landless unemployed and/or under-employed rural labourers were social-economic problems of tremendous magnitude and complexity with which India also had to contend. These social problems did not exist in the U.S.A., when its revolution in yield and production occurred. India was further handicapped by having to cope with developing, disseminating and gaining acceptance of the new high yield technology by millions of 2 to 5 acres small primarily subsistence farmers employing traditional agricultural methods, who all too often were accused of being perverse, immutable, and resistant to change, according to the oversophisticated opinions of many bureaucrats, scientists, "pseudo-scientists" and other "experts" of both the national and international variety. United States agriculture was also spared the difficulty of coping with this problem. And finally Indian agricultural development was handicapped far greater than that of the U.S.A. by the shortage of capital for investment in the infra-structure—fertilizer factories, energy and power, irrigation projects and equipment, transportation systems, storage facilities and schools and institutions of higher education—which are essential to transforming a traditional agriculture into a modern agriculture.

It is especially gratifying to me—and, I'm quite certain, even more so to most of you in this audience—that this revolution in cereal production has been achieved despite all the aforementioned obstacles and despite the dire predictions a decade ago by doom-sayers from the U.S.A. (and other developed countries). Two from the U.S.A., in particular, made their views known both nationally and internationally and stated categorically that the Indian food and population problem was insoluble and hopeless. They advocated either "triage" or the "life boat" approach for American national survival, and advocated discontinuing grain shipments to India, as well as to several other countries whose predicament they also classified as hopeless.

How wrong they were! From an ethic standpoint their position is immoral, deplorable and indefensible. From a realistic point of view their position was both impractical and foolhardy. It failed to recognize that

the world of the 1970's is made up of a large number of independent but ever more interdependent nations than was the case in the 1920's and 1930's. In the world of today there is not a single nation that is self-sufficient within its own borders, in all essential non-renewable and renewable commodities. International trade is increasingly important and essential to all nations.

I rejoice with all of you in the progress that has been made in increasing Indian cereal production faster than population growth in recent years. However, I hasten to remind you that although a few battles against famine have been won, the war against hunger, poverty, ignorance and human misery must continue unabated. We must cope with the relentless unmitigated advancement of the human population monster on many fronts, which makes it increasingly more difficult to provide the basic essentials for a decent human life—adequate food, clothing, housing, employment, education, medical care—to all who are born into this world. How many should be born into this world and how fast they should come on the stage of life is another matter, which I will touch on briefly in the closing minute of this lecture.

WHAT LIES AHEAD FOR INDIAN AGRICULTURE

Agricultural Production in the Short Term-1980–1990

If complacency is avoided, or banished from wherever it is already stealthily invading policy and planning, research, extension, seed multiplication and credit institutions, there is every reason to believe that India can remain self-sufficient in cereal grain production for the next decade or two. It now has the potential of also becoming a modest exporter, if production is aggressively pursued. This prediction assumes that the political leadership will continue to promote policies that will stimulate agricultural production and research while at the same time preventing the stifling hands of bureaucracies from slowing progress. It will require continued dynamic expansion of fertilizer production and irrigation.

In order to stay ahead of the growing demand for cereals, production of maize, sorghum and millet will need to be increased more rapidly than they have been increasing in the past decade so as to broaden the base of the revolution in cereal production beyond wheat and rice which, up to the present, have carried the major burden toward achieving self-sufficiency.

The timely release, multiplication and widespread distribution, of new rust resistant wheat and rice varieties must be continued in an orderly opportune way, to replace varieties that have become susceptible, if destructive epidemics are to be avoided. High yielding multi-line varieties should seriously be considered for use as one way of reducing risk from airborn epidemics in autogamous crop species. The greatest danger is from complacency among research scientists and lack of dynamism and aggressiveness in the seed multiplication and distribution agencies.

Aggressive research must be continued on fertilizer and soil fertility for all of the major cereals so as to adjust recommendations to meet changing nutrient needs. Studies to monitor and determine the requirements of minor nutrients, and their application where economically justifiable, will likely become more important in the future, for maintaining or, also possibly in some cases, for increasing yields.

More aggressive research, involving both agronomic practices and use of chemicals, to reduce losses from weeds is urgently needed.

More research is needed to develop safe, efficient, economic control practices against insects and diseases (wherever or whenever disease resistant varieties are unavailable) and to employ them wisely before serious crop losses occur. All methods of control should be considered in developing effective plans to protect our crops, namely : resistant varieties, rotation of crops, dates of planting, biological control, male-sterile technology in some insect species, and the proper use of insecticides, fungicides, and bactericides. If we are to protect our crops we should not be overwhelmed by biased over zealous emotional "neoecologists" and extremist in the environmentalist movement. Above all we should not forget the increase in human misery that resulted from the explosive increase in malaria, in many semi-tropical countries, following the banning of DDT, for vector control. The abandonment of the use of DDT before a satisfactory substitute was available, was based on flimsy evidence promoted by a small group of extreme environmentalists, in support of the thin egg shell hypothesis. It was claimed that DDT fostered the extinction of a number of bird species, including the brown pelican, because of the upset of their calcium metabolism resulting from DDT in the food chain. To avoid being misunderstood let me say I am against the wreckless use of agricultural chemicals, just as I am opposed to the careless use of medicine, or as I deplore and reject the use of drugs to alleviate boredom and permit some foolish individuals to take a trip to an ill concieved temporary dreamland. The wise use of agricultural chemicals, like medicine, must be approached and managed by weighing benefits against risks. We must continue to have available agricultural chemicals if we are to meet the growing demands for food, and we must use these products correctly.

Finally, in order to assure self-sufficiency of cereals over the next decade it will be absolutely necessary to carry a large reserve or buffer stock of grain in storage as protection against a poor monsoon. I'm certain that the protection that will be provided by the current 22 million ton buffer stock which will carry the nation through the next critical 7 or 8 months will become a valuable lesson for the future, not only for India but also for many other countries.

India continues to be deficit in edible oil production. I have witnessed on experimental stations in recent years the development of improved technology that appears, to me, to be capable of substantially increasing

the yield and production of the winter oilseed Brassica spp, and of the summer oilseed crops ground nut, soybeans and sunflower. What is needed now is an aggressive demonstration and production campaign carried out on farms, such as was employed successfully with wheat and rice in the late 1960's and early 1970's. If such a campaign is vigorously launched and supported, it would appear to me, that India has the potential to become self sufficient in edible oil within 5 to 7 years.

Similarly, I have seen, on experiment stations, what appears, to me, to be improved economically viable technology, including new superior varieties of gram, pigeon pea, peas, mung beans and lentils, capable of substantially increasing yield and production if employed widely on farms. Just as in the case of oilseeds, what is needed now is a dynamic on farm demonstration and production compaign. If such a campaign is launched and executed it is very probable that India can achieve self-sufficiency in pulses within 5 to 7 years.

Potentially useful technology serves no useful purpose—nor is there any justification for having developed it—as long as it lies dormant and unused on experimental stations. It is a waste of scarce resources.

Agricultural Production in the Long Term—1980-2035

I am convinced that India has the potential to produce enormous quantities of food during the next half century. I would venture to guess that it has the potential for increasing its estimated 1978–79 record production of 130 million metric tons of food grains by three or even four times that figure during the next five decades. Call this a dream, if you will, but it is not much more of a seemingly impossible dream, than the one which I dreampt in 1963, after having my first detailed view of India's wheat production problems. At that time I dreamed it might be possible to double wheat production in 15 years. That dream became reality in 8 years. Even more unbelievable, wheat production more than tripled in 15 years. How happy I am to have lived to see it happen ! Since I won't be permitted to be around 50 years from now, to see what happens to my more fanciful present dream—unless I do so in another reincarnation—I will sketch for you the dream I am now living with.

Whether this dream or vision will materialize will depend primarily on whether or not the following projects are planned and materialized. The integrated development of the Ganges, Brahmaputra and Barak Meghna river basins is essential if this dream is to materialize ! These vast development projects must, by necessity, be multinational schemes developed for the mutual benefit of and involving the governments of India, Bangladesh, Nepal and Bhutan. The development cost will be enormous and can only be financed by a consortium with the investment spread over three to five decades.

The dam and barrages will collect and impound the monsoon run-off

is now recognized as being important. Located near the head of the principal drain is a huge monument with the names of political leaders and engineers embossed on a huge bronze plaque. Such plaques formerly only graced the impressive fronts of dams and other prestigeous public work projects—but never ugly dirty drainage ditches. No prestige was formerly associated with having your name inscribed at a dedication on a dirty drainage ditch. Things have changed ! Today high value can be associated with ugliness if it provides a valuable public service.

To make my dream come true will require the unfailing continuous effort of four generations of officials, agricultural scientists, hydraulic, electric and chemical engineers, foresters and farmers. It will include those who are currently fighting the food production battle, the young who are in their formative years, and the third and fourth generation that are still to be born.

THE POPULATION MONSTER

In closing I would be remiss of my duty if I failed to clearly speak out about the magnitude of the world population growth problem and its implications for food production and the well-being of mankind. World population was probably about 15,000,000 at the dawn of agriculture about 12,000 years ago. It doubled 8 times, or increased 256 times, since the beginning of agriculture, to arrive at a population of 4 billion in 1975. Today it stands at about 4.2 billion and appears to be increasing at a rate of about 72 million per year. If population growth were to continue at the rate it was increasing in 1975, when population reached 4 billion, it will double to 8 billion in 40 years or by the year 2015. There is, however, some evidence that growth has slowed somewhat in recent years, which might imply, were this trend to continue, that it would require 60 years to double or that 8 billion would not be reached until the year 2035. If one assumes that there will be a further marked decline in growth so that it would require 80 years to double, it would advance the date of doubling to 2055, which I feel is unduly optimistic. Take your choice 40, 60 or 80 years for doubling from 4 billion to 8 billion, anyone of them presents a terrific challenge on the food production front.

It took from the beginning of agriculture up until 1975 to produce a record harvest of 3.3 billion metric tons, uncorrected for moisture, of all of the different kinds of food. Of this total 98% was produced on the land and only 2% harvested from the ocean and inland waters. Most of the world's gradual increase in food production up until 40 to 70 years ago, resulted from increasing the land area under cultivation as the demand for food increased. At the present time many densely populated countries have little additional land that is suitable for agriculture that can be rapidly brought under cultivation, so this implies that most of the future increase in food production must come from increasing the yields per acre on land already under cultivation.

It took from the beginning of agriculture 12,000 years ago through the combined approach of increasing the land area under cultivation and increasing yields per acre to gradually increase food production to the aforementioned record level of 3.3 billion tons. Now in the short period of 40, 60 or 80 years we must double that production to even maintain per capita consumption at the inadequate level of 1975. There is obviously no justifiable room for either complacency or procrastination in efforts to improve world agriculture.

Can the production of food and fiber be doubled in the next 40 years ? I believe it can, provided world governments give high enough priority and continuing support to agricultural production. In any case, those of us working in agricultural production are at best involved in a holding operation against famine while the population monster is being tamed. To hold the line we must expand our scientific knowledge and improve and apply better technology if we are to make our finite land and water resources more productive. This must be done promptly and in an orderly way if we are to meet the rapidly growing needs for food without, at the same time, unnecessarily degrading the environment and crowding many species into extinction The food production goal can not however be achieved if we are unduly obstructed by extremists and doom-sayers in the environmentalist movement. Status quo attitudes and the idea that the known is comfortable and the unknown is fearsome can be both deceiving and dangerous. I'm sure that we can all agree that the agricultural technology that was adequate to feed a world population of 2 billion in 1930 would be disastrous if we attempted to use it to produce the food for today's 4.2 billion people. There is no way we can discard today's agricultural technology and go back to the technology of the "by-gone good old days", and avoid disaster. Those who advocate such an approach to today's complex food production problems are living in a fools paradise. If we listen to them civilization will be undermined and collapse.

It is my belief that we must hold the line on the food production front while we strive to slow population growth. At the same time I believe that all who are born into this world have a moral right to the basic ingredients for a decent humane life. How many should be born and how fast they come on stage is another matter. This latter question requires the best thinking of all of us. In my opinion, if we are to survive in a world in which our children and their children will want to live, and more important, be able to live this problem must be confronted and dealt with in a non-emotional, humane, forthright manner.

Scientists and educators can no longer remain aloof from these complex problems. We must influence religious and political leaders to face up to and tame the population monster or loose the game by default. It is latter that most of us believe it to be, or at least are willing to admit.

and the snow melt—estimated to be somewhere between 900 million and one billion acre feet annually, 80 per cent of which now flows unused into the Bay of Bengal, but which at times also provokes disastrous floods that destroy crops and take a heavy toll of lives on its disastrous rush to the sea.

The annual flow of the three river basins has been estimated to have a potential hydro-electric generating capacity of 50 million kilowatts, which will be used for powering industries, energizing pumps and wells for irrigation and for fixing nitrogen from the air into ammonia and other forms of nitrogenous fertilizers via the Haber process. The impounded water will be used for irrigation within these river basins wherever and whenever needed. The surplus could be transferred by pumping to the drought striken area of other watersheds in several southern provinces.

Dr. K. L. Rao, the former Minister of Irrigation and Power in various reports, Mr. B. G. Verghese in his treatise *Gift of the Greater Ganga*, and Mr. John T. Tucker in his publication *Water for Survival Projects for Peace* have, like me, all had this same dream.

But my dream also visualizes something more—a huge green belt of trees now growing on the steep eroded slopes of the watershed that formerly had been denuded of forests and unwisely converted to low yield subsistence agriculture, which in turn has contributed enormously to erosion, silting of reservoirs, and canals and flows in the plains below. In my dream the erosion and silting have been reduced greatly. Perculation of much of the rain into the soil has been facilitated by the forest cover. The water in the reservoirs is blue rather than chocolate brown. These formerly unproductive lands, now reforested produce firewood, lumber, pulp and paper, nuts and fruits. They provide employment and a better standard of living for large numbers of hill people. They have again become a friendly habitat for many species of birds and animals, as have the streams, rivers and reservoirs for fish. Tourism and recreation is invading the pleasant mountain landscapes and the green forests. It brings with it more income for the hill peoples.

Now I awaken from my dream, startled, and ask "but who planted those many billions of trees ?" "Certainly not the Ministry of Agriculture and Forestry for they would never have had either sufficient funds or manpower to have accomplished such a gigantic task".

Now permit me to digress from my current dream for a few moments, as I glance at you—my distinguished audience—I see among you my long-time friend Ex-Minister of Agriculture Shri C. Subramanium, who, in 1966, had both the vision and political courage to make the tough decision to import 18,000 metric tons of Mexican dwarf wheat seed, against the advise of many experts. He too had a dream, the hope of breaking out of the vicious circle of food shortages and famine. Look what has happened ! I'm certain that the results already achieved, have surpassed even Minister Subramanium's fondest dream.

And now Honorable Minister of Defence, Shri C. Subramanium, the only way that I can hope to have my dream of reforesting of the vast denuded Himalayan watersheds become a reality, is if you, as Minister of Defence, and a number of your future successors, join hands with the Ministry of Agriculture (and Forestry) and jointly pool enough of your resources and manpower to plant and protect one billion trees annually. It is a worthy cause and a target that is achievable. I firmly believe that military agencies—like civilian agencies—have social responsibilities that trascend that of protecting the nation against foreign attack.

More than 43 years ago, during the depths of the economic depression in the U.S.A., as a young forester, I participated in a reforestation program under the Civilian Conservation Corps. This was an emergency agency and program. It was jointly administered and managed by the Ministry of Defense (U.S. Army), which built and managed the barracks and provided the mess and discipline while the young recruits were in camp and the U.S. Department of Agriculture (Forest Service) which provided the leadership and technical direction for the crews during the working hours in the forests—planting trees, sowing grass and building brush dams to reduce soil erosion, building public camp-grounds, and constructing trails and roads. The young recruits were 17 to 19 years old unemployed, underprivileged youths from the low income neighbourhoods of the major cities.

Two years ago I revisited some of the forest plantations that we made in 1935 and 1936. These plantations are impressive. It was, I'm convinced, both a good investment in human resources—providing constructive employment for the young unemployed—but also a wonderful program in forestry and conservation. This too was a dream—of President F. D. Roosevelt—that has born fruit.

And now friends, permit me to return once again to my current Indian dream. I see above me at many places in the green forest covered mountains, reservoirs with hydro-electric power plants. Moreover, I see many factories associated with these hydro-electric power plants. They are employing an improved modification of the Haber process to produce enormous quantities of ammonia and other forms of nitrogenous fertilizers. Now I turn and gaze at the lowlands and see a never ending deep green lush uniform carpet of green fields of wheat. They cover the irrigated lowlands below as far as the eye can see.

I see, also, that another change has taken place. I do not now see large white salt covered waterlogged areas devoid of crops as were common three decades ago. Now the reason for this change becomes apparent. The beautiful green fertile irrigated lowlands now are not only criss-crossed by canals, but also by a second network—a network of drains. The drains have leached away the salt, and corrected the water-logging and transformed barren sterile land into beautiful green fields of wheat where none grew before. Finally, it remains for me to comprehend why this immaculate net—