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# PLANT GENETIC RESOURCES AND POLICY IMPLICATIONS FOR A CHANGING AGRICULTURE

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## ROLE OF PLANT GENETIC RESOURCES

Scientific research in post-independence India has made many significant contributions—one of the more important of these has been in the field of agricultural production. India in the early 1950s was agriculturally a backward country with very low crop yields, accounting for the country's endemic poverty. There has been a marked improvement in agricultural production, especially during the past 25 years, although much remains to be done. Following this improvement, India became in 1991 the second largest producer of rice in the world, the third largest producer of wheat, the second largest producer of sugarcane, the fifth largest producer of cotton and the fifth largest producer of potatoes [1]. Production of many other crops including some of the coarse cereal grains like pearl millet, oilseeds like rape-seed, mustard, and fruits and vegetables like apples, grapes and tomatoes has also seen a major increase.

The production advance has been made possible by inputs of several kind, including the large scale development of irrigation and use of chemical fertilizers, pesticides and improved farm implements. The motivation, however, for these large investments into the centuries old traditional agriculture of India has been provided by plant genetic resources which underlie the high yielding varieties programme. Nothing contributes as much to the productivity of modern agriculture as the genetic potential of the new varieties, for without this potential, all the other inputs could not be used efficiently.

The process of identifying plant genetic resources started nearly ten thousand years ago with the first domestication of plants in the valleys of Euphrates and Tigris [2]. Modern plant breeder makes use of the land races selected by generations of farmers for traits useful to man such as disease and pest resistance, drought tolerance, good grain quality and higher

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yields. With the knowledge of Mendelian genes and of their segregation and recombination, the breeder is able to synthesize varieties giving higher yields and combining other desirable characters. The classical example is that of the dwarf varieties of wheat and rice released in the 1960s which had a major impact on food production in India and in many other developing and developed countries. The dwarf varieties of wheat and rice owe their high yields to genes which make the crop plants more responsive to modern farm inputs like the chemical fertilisers. These genes which have now spread to all parts of the world where wheat and rice are grown were first located in Japan and China, respectively. Some social scientists believe that millions of people in developing countries like India would have died of starvation if the high yielding varieties of wheat and rice had not been developed and grown widely at a time when the population in many of these countries had started to multiply rapidly following the advent of modern medicine [3].

With all these recent advances, India's agricultural problems are far from over as the population pressures continue to build up. A second generation of high yielding varieties will be needed to feed the growing population. And as the world's environment changes with global warming, increased incidence of ultraviolet radiation following ozone depletion, and drier climates in many regions of the world, the scientists will be searching for new sources of genetic diversity to be able to respond to the technological challenges of future agriculture. Plant genetic resources will be required, as in the past, to provide the raw material for the new crop varieties.

## THE CONTRACTION-EXPANSION CYCLE OF GENETIC DIVERSITY

If plant genetic resources are extremely important for making sure that future agriculture continues to be responsive to increasing human needs and environmental changes, it becomes important that there is no erosion of genetic diversity. And that raises some important policy issues. The fundamental question is: do we want a genetically uniform kind of agriculture in the different countries of the world on the lines of industrial production? Or, alternatively, do we need a high-yield agriculture which still combines a great deal of genetic diversity in it? The answer to this question has important implications for the organisation of plant breeding programmes in the different countries.

In the past ten thousand years the world has seen a cycle of contraction and expansion of genetic diversity in agriculture with an inexorable move towards contraction during its current phase. The process of contraction of genetic diversity starting with the first domestication of crop plants. Preceding such domestication, the early man, like the tribal people even to this day, was harvesting seeds and fruits from a much larger number of species than those which have found a place in modern agriculture [4]. Of the thousands of species of plants known to us, modern man derives his food for the most part from 25 to 30 species which include wheat, rice, maize, barley, oats, sorghum/millets, soybean, other beans, pea, chickpea, peanuts, banana, citrus, tomato, sugarcane, cassava, potato, sweet potato, yams, five oilseed types and a few beverages [2]. The tendency in more recent years has been to further restrict the sources of food with more and more people all over the world taking to wheat and rice as their staple diet.

## THE GOLDEN AGE OF GENETIC DIVERSITY

This contraction of genetic diversity at the species level was counteracted strongly by expansion of genetic diversity at the intraspecific level as agriculture, following the first domestication of plants, started to spread to different regions of the world with human migrations and travels of great explorers, supplemented in more recent years with the development of modern means of transportation, which have resulted in greater political, economic and social contacts between people of different countries. It was the spread of agriculture in these early years which saw a great movement of seeds and planting material from their centres of origin to entirely new environments. This process has continued in our own time in a more organised form. This movement of seeds to new ecological niches unleashed a process of selection and adaptation, making use of the variability generated by genetic recombination and gene mutations. Just as Darwin's finches came to be differentiated into different species in the various islands in which they found themselves on migration from a common stock, so did the newly moved genetic material of crop plants differentiate into new landraces, as it was subjected to selection by different human populations in various regions in response to local preferences and environments [5]. The evolution of crop plants in new environments over the past several thousand years is expected to have taken the form of development of adaptive gene complexes, which would vary with the different landraces. The past ten thousand years have thus been millenia of expansion of genetic diversity—a golden age as far as the development of new plant genetic resources is concerned.

## HIGH YIELDING VARIETIES AND INCREASING GENETIC UNIFORMITY

This process of expansion of genetic diversity, however, was not to last and contraction started again nearly 100 years ago with the emergence of scientific techniques of plant breeding made possible by the rediscovery of Mendel's laws of heredity. The result has been the replacement of hundreds of landraces and traditional cultivars by genetically improved varieties with higher yield potentials and other desirable traits. The process has gathered momentum during the past 25 years with the discovery of plant type genes in wheat and rice and in other important crop plants leading to the development of a high-yield agriculture [6].

Not only have the agricultural scientists been remarkably successful in creating these very favourable gene–environment interactions, they have also succeeded in developing widely adapted varieties. Thus, some of the high yielding varieties of wheat developed at CIMMYT in Mexico have been cultivated in a number of other countries including India, Pakistan, Afghanistan, Iran and Turkey [7]. Similarly, the IR-8 variety of rice developed at the International Rice Research Institute in the Philippines spread in the 1970s to many countries in South Asia, Southeast Asia and the Far East [8]. It is this combination of plant breeding for high yields and wider adaptability that has resulted in large scale replacement of the traditional cultivars and landraces evolved over the past several thousand years. Within a short period of about 25 years the new high yielding varieties have spread to cover millions of hectares of land. Thus, the dwarf, high yielding varieties of wheat which trace their origin to some of the parental material developed at the International Maize and Wheat Centre (CIMMYT), Mexico, had spread by 1983 to an estimated 48 million hectares of lands in the developing countries. This means that nearly 50% of the total area planted under wheat in these countries was now under wheat varieties evolved from a common germplasm source. Similarly, the dwarf varieties of rice which could be traced in their origin to the germplasm developed at the International Rice Research Institute had spread to over 40 million hectares by 1983 and if one included similar semidwarf varieties in China, the area covered was as much as 75 million hectares [9]. It is clear that the replacement of the landraces and local cultivars had proceeded on a scale large enough to undo the whole process of development of genetic diversity over the past ten thousand years.

## GENE BANKS AND THE CONSERVATION OF GENETIC DIVERSITY

Several countries recognising the value of plant genetic resources for the development of their agriculture had started to make collections of germplasm from different parts of the world. The foremost explorer and collector of these resources in recent times has been the Russian geneticist Nikolai Vavilov who organised collecting expeditions in the USSR and in some 50 other countries of Asia, America, Northern Africa, Europe and the Mediterranean region during the 1920s and 1930s. It was Vavilov's work in the course of these expeditions which led to the discovery of geographic Centres of Diversity and Origin of Crop Plants [10]. Vavilov observed that crop plants and their relatives are not distributed at random and that different species show maximum diversity and distribution of landraces and wild relatives in specific regions. Some of these countries developed the concept of gene banks where the seeds of landraces and local varieties and their wild relatives could be stored for use in future breeding programmes. Most of these early gene banks were set up in the developed countries like Germany, Canada, Japan, Australia and, above all, in the Soviet Union and the United States, the two countries which continue to maintain the largest collections of plant genetic resources.

The concept of gene banks has gained importance in the last 25 years after the process of erosion of genetic diversity threatened to assume serious proportions with the development and release of high yielding varieties of wheat and rice, and of other crops. The Food and Agriculture Organisation of the United Nations which had earlier spearheaded work in the field of plant genetic resources in collaboration with its member countries agreed in 1974 to co-sponsor with the Consultative Group on International

Agricultural Research the setting of a new institution, the International Board of Plant Genetic Resources (IBPGR) [11]. The Board was asked to assist the developing countries in making collections of their genetic resources and to organise gene banks for this purpose. This has been a highly successful venture. During the first 10 years of its existence, IBPGR had helped to organise collection missions in 88 countries.

The collections made in the course of these missions have covered 138 species and they have been placed in gene banks of 91 countries. The Board has provided equipment for gene banks in over 20 developing countries and it has also started work to develop germplasm collections of vegetatively propagated crops. The Board's most important contribution has been as a catalyst by strengthening national research programmes in their plant exploration and collection work. The world wide collections in national and international gene banks now total over 2.5 million samples of cereals, 36,900 of food legumes, 21,500 of forage legumes and grasses, 13,700 of vegetables and 74,000 clones of root crops, and they continue to be augmented [12].

### FUTURE STRATEGY FOR PLANT GENETIC RESOURCES

The threatened loss of the world's plant genetic resources has been largely averted with timely action by the national agricultural research systems and the international agricultural research centres working in close collaboration with the IBPGR. It has been possible to create a chain of gene banks distributed in different regions of the world. There are not many examples of the world community of scientists responding in such a cooperative manner in warding off the impending loss of some of the world's most valuable genetic material of crop plants. While these efforts must be commended, we must still ask the question whether gene banks provide a permanent solution to the problem of conservation of the rich diversity of plant genetic resources which world agriculture will continue to need.

### A PARTIAL SOLUTION

There are three fundamental reasons why gene banks provide only a partial solution to the problem. First, the sustainability of many of the gene banks on a long term basis with their requirement of sophisticated equipment and high maintenance costs remains in doubt. Many of these facilities have been set up in recent years with support from the donor agencies. Ultimately, however, they will have to be funded, maintained and managed by the national systems in developing countries. It is not at all certain that the seed samples contained in these gene banks will continue to be conserved in a viable condition for many years to come. Second, the concept of collection of plant genetic resources as it has evolved during the past 40 years has been based on the recognition that plant genetic resources are a common heritage of mankind and they should be freely exchanged between the scientists of different countries. This principle of common heritage, as we shall see, has come under serious threat in recent years with the evolution of the concept of intellectual property rights which are now proposed to be extended to living forms. Third, and perhaps more important, genetic diversity stored in gene banks serves only a limited purpose. It is reassuring to know that the variability exists and can be mobilised as the need arises. In practice, however, only a small fraction of the stored genetic variability is used by the plant breeders [13]. Most of the time they are content to use their limited working collections and it is too much to expect that a significant part of the thousands of accessions stored in the gene banks will be utilised in the course of the hybridisation programmes either at present or in future. Indeed, the very evaluation of this vast amount of stored material presents a formidable challenge.

THE PROBLEM OF VULNERABILITY

It should also be clear that the establishment of the gene banks has not made world agriculture less vulnerable to disease and pest epidemics. Despite the storage of vast amounts of genetic variability in gene banks, crop plants in the world agriculture continue to become more uniform. There are examples of disease epidemics causing serious loss to agricultural production in many countries because of the absence in farmers' fields of the kind of genetic diversity which was provided in earlier years by the different landraces. Thus, the wheat crop in India, Pakistan and several other countries during the past 25 years has been affected by rust and other epidemics in some years and it is only because of a very vigorous programme of breeding and replacement of varieties that the epidemics have not become more common [14, 15].

RECREATING DIVERSITY

The scientific challenge today is to take out much of the conserved variability from the gene banks and to incorporate it into a wider range of crop varieties to be recommended to farmers. How can this be done? It is not possible to go back to the traditional agriculture of land races and low-input farming. Traditional methods of farming with their low yields are no longer relevant to a world population which would be soon reaching the 6 billion mark and may double in another 50 years. The answer lies in going back to essentially the same kind of mechanisms which helped to evolve a wide range of genetically diverse varieties in different regions of the world. In traditional agriculture, as we saw earlier, this happened through the process of adaptive distribution of genotypes. In modern agriculture this should be possible through a decentralised process of crop breeding. Thus, the world will need a different strategy of crop improvement than the one which it has followed in the past 25 years. Twenty five years ago, the national research systems in developing countries were weak, and the highly centralised crop breeding programmes organised by the International Agricultural Research Centres like CIMMYT and IRRI appeared to be the most logical response to the problem of massive food shortages in these countries. Today the situation is quite different. Following major investments in strengthening them during the past years, the national institutions can now be given much greater responsibility. A new kind of relationship is needed between the international agricultural research centres and the national agricultural research institutions of the developing countries.

The national agricultural research system of India, coordinated by the Indian Council of Agricultural Research, provides a good example of the new strategy to be developed. Most of the crop improvement work in India in recent years has been in the form of nationally coordinated programmes involving the state agricultural universities and the central institutes of the ICAR [16, 17]. A major objective of these programmes is the development and release of a large number of high yielding but genetically diverse varieties adapted to different agro-ecological regions of the country. The wheat geneticists in India have identified a large number of genes which confer resistance against different races of rusts [18]. It is the mobilisation of these genes in different varieties which is helping to provide the diversity needed for creating barriers against the spread of diseases. This approach has been described as the building of a multilineal complex of genetically diverse varieties distributed in space and time to contain disease epidemics [19].

Most countries would be expected to have a decentralised breeding programme of this kind so that the world as a whole is saturated with a very large number of locally adapted and genetically diverse varieties. They will be very different from the traditional landraces in the sense that these varieties will have been evolved for high yields and for response to modern farm inputs. There will be a large number of diverse parental lines going into these local breeding programmes quite different from the present practice of distributing breeding material globally from a single international agricultural research centre. These centres, it must be recognised, made an important contribution when the food situation in the developing countries was grim and the national programmes were weak. But they were established to buy time for the national systems to take up their own responsibility. The time has now come for some of the responsibility to be handed back to the national programmes.

In the changing policy environment for plant genetic resources, the international agricultural research centres should be requested to take up responsibility of a different kind. They should be asked to organise international gene banks for different regions of the world. This becomes particularly important as the earlier concept of common heritage is replaced by one of the plant genetic resources being considered as part of the sovereign inheritance of each country. In these circumstances it is important that a member of international centres will become a dependable sources for the collection and distribution of plant genetic resources.

Secondly, as the world population continues to multiply it will become increasingly important to identify new sources of higher crop yields. The agricultural scientists have been very successful in the past 25 years in creating high genetic potential for yields in crops like wheat, rice, maize, sorghum, millet, oilseeds, sugarcane, cotton and potato. It is generally recognised now that varietal yield improvement in most of these crops during the past 25 years has been derived largely through the process of redistribution of dry matter [20]. In other words, using plant type genes, it has been possible for plant breeders to divert more and more of dry matter into the grains improving in this way the grain-to-straw ratio. The total dry matter production itself has mostly remained unchanged. In several crop plants, scientists are now able to recover as much as 50% of the dry matter in the form of grains. There is a limit, however, to which this proportion could be further increased. It is becoming clear that major improvements in crop yields in the future will have to come from increased dry matter production. We need plant genetic resources which would provide the genetic variability for rates of photosynthesis to further increase agricultural productivity.

The International Agricultural Research Centres would be expected to provide leadership in identifying plant genetic resources of this kind through a massive screening program of the germplasm stored in the gene banks. The centers in this way could help bring about another major advance in the productivity of crop plants. The plant genetic resources should also be evaluated for other useful traits like multiple and durable sources of disease and pest resistance. The past 25 years have seen major emphasis on the collection and conservation of genetic diversity. The next 25 years should see a similar emphasis on the evaluation and exploitation of the genetic variability now available in the gene banks.

## PLANT GENETIC RESOURCES AND THE FUTURE DEVELOPMENT OF WORLD AGRICULTURE

It took ten thousand years to develop world agriculture to its present level on the basis of free movement and exchange of plant genetic resources. There is hardly any country in the world whose agriculture has not gained immensely from genetic diversity of plant material introduced from other countries. It became clear from the pioneering work of Vavilov that the centres of genetic diversity of most of the crop plants of world agriculture are located in the developing countries which for this reason have been described as gene rich. Most of the crop plants of European and North American agriculture are introduced species. A classical example is that of Australia whose entire agriculture is based on introductions of genetic resources made during the post-colonization period. The developing countries have also gained from the introduced wealth of plant material from different regions. Potato, for example, is now widely cultivated in Asia following its introduction from the Andean region of South America in the post-Colombian period.

## COMMON HERITAGE NO MORE

It is this great movement of plant genetic resources across national borders for hundreds of years which led to the concept that plant genetic resources are a common heritage of mankind. Recognising this, an FAO Conference adopted in 1983 an International Undertaking which stipulates that plant genetic resources should be explored, collected, conserved, evaluated, utilised and made available without restrictions for plant breeding and other scientific purposes [21]. Within less than 10 years of its adoption, however, this International Undertaking has been seriously undermined with the signing of the Biological Diversity Convention at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro last year. The Biodiversity Convention describes plant genetic resources as the national heritage of each country and has placed access to them under the sovereign control of individual states to which they belong. The access to genetic resources within the territory of a particular country will, thus, have to be negotiated on mutually agreed terms. The Biodiversity Convention also, of course, makes specific provisions for conservation and exchange of genetic resources but the fact remains that the earlier open door policy as enunciated in the Common Heritage Undertaking may no longer prevail. Different countries will now be called upon to take appropriate legislative and regulatory measures to determine the movement of their plant genetic resources.

## INTELLECTUAL PROPERTY RIGHTS

The reasons for this reversal of the open door policy are to be found in the distrust of the developing countries arising out of some recent developments in the field of intellectual property rights. These developments suggest that intellectual property rights in the form of patents, which so far have been available to innovations in the field of industry, may now be extended to agriculture to cover seeds of new crop varieties, especially those developed through the application of modern biotechnology [22].

The concept of intellectual property rights for providing protection to improved varieties of crops is not entirely new. Plant breeder's rights in its present form were introduced in Europe in the 1960s largely to offer incentive to private seed companies to invest in crop improvement research. Under the provision of this legislation, seed companies developing new plant varieties were given exclusive rights for the sale of seeds of those varieties. However, the plant breeder's rights clearly provided that farmers were free to save and replant their harvested seed and other plant breeders could freely make use of the protected varieties in their hybridization programme to develop new types. What is now being proposed, however, is quite different. If patents are extended to crop varieties, neither the farmers nor the future plant breeders will have the right to make use of the seeds of the protected varieties without the permission of the original breeder for which payments may be demanded.

The developing countries are not happy with the extension of industrial patents to plant varieties [23]. They argue that most of the plant genetic resources which private seed companies in the developed countries use came originally from the developing countries.

Secondly, they argue that biotechnologists producing genetically engineered varieties use techniques developed in the course of publicly funded research. Thus, the recombinant DNA technology marks the culmination of a number of major discoveries in biological and analytical sciences during the past 40 years. These discoveries continue to be in the public domain. Similarly, the transformation technology for the production of transgenic varieties has been widely available. It will, therefore, be difficult to prove that the new varieties are based on a new invention made by the breeder. The controversy, however, continues and the hope is that in the next ten years the techniques of genetic engineering will have advanced so much that they will become a standard practice, and for this reason, claims of technical innovation and novelty will not be legally sustainable [24, 25].

## INDIA AND PLANT GENETIC RESOURCES

Of the 12 centres of genetic diversity and origin of crop plants described by Vavilov, one is the Hindustan Centre including the Indo-Burma region [26]. The region is home to such important plants as rice, several species of pulses, citrus, mango, yams and several vegetables and spices, in addition to numerous medicinal and aromatic plants [27]. These rich genetic resources have made a valuable contribution to the development of agriculture both in India and in many other countries. Thus, when the high yielding, dwarf varieties of rice developed at the International Rice Research Institute were found to be susceptible to brown plant hopper, the genes for resistance were identified in the Pattambi rice collection of Kerala. These genes now find a place in the pedigree of a number of modern rice varieties. Another good example is that of genes for useful traits in the wild species of sugarcane which were exploited to such good effect by Venkatraman [28] at the Sugarcane Breeding Institute of India in Coimbatore. The improved sugarcane varieties from Coimbatore have been introduced in many sugar producing countries of the world.

Indian scientists, in turn, have made good use of genetic diversity introduced from other parts of the world. The dwarf varieties of rice and wheat introduced in the mid-1960s provide a particularly good example. In more recent years, sunflower and soybean have become important crops in India with the introduction of improved varieties from several different countries.

## FUTURE DIRECTIONS

Plant genetic resources research in India started with a modest beginning in the 1950s at the Indian Agricultural Research Institute when a new section was created for this purpose [29]. It is now being coordinated by the National Bureau of Plant Genetic Resources (NBPGR) set up in 1978 by the Indian Council of Agricultural Research. The Bureau with its headquarters in New Delhi and 11 Regional Stations in different parts of the country has been in the process of establishing a National Gene Bank which when completed will have facilities for long-term storage of 8,00,000 seed samples. Currently, the Bureau maintains a base collection of 1,73,098 seed samples in long-term storage at $-20^{o}C$ [30].

Much of the plant genetic resources work in India, as in other parts of the world in recent years, has been concerned with the collection and maintenance of seeds of local varieties and landraces threatened with extinction following the development and release of high yielding varieties. This phase would be soon completed. The National Bureau of Plant Genetic Resources must now provide support for continuing the process of modernisation of Indian agriculture. It was the discovery and introduction of plant type genes in wheat and rice leading to the development of high yielding varieties, which became the driving force for decisions to modernise Indian agriculture [31, 32]. There is no reason to believe that plant type genes of a similar kind will not be available in many of our other important crop plants like the oilseeds and pulses. A systematic programme of collection, introduction and evaluation of plant genetic resources will be needed for this purpose. The National Bureau working in close collaboration with the national coordinators of different crops will be called upon to help identify genetic variability of this kind following a mission-oriented approach. We need to identify gaps in the availability of genes for developing high yielding varieties of different crops and then organise a major collection and evaluation programme to find such genes.

There are other gaps in Indian agriculture where plant genetic resources have a particularly important contribution to make. Thus, a potential growth area in Indian agriculture relates to temperate fruits like the almonds, wallnuts, olives, grapes and peaches, commonly found in the different Mediterranean countries. Many of these fruit plants can be expected to do well in the Himalayan belt of India provided a major programme of introduction and testing of genetic variability is organised. We need to test hundreds of different genotypes based on introduced wealth of genetic resources to identify those which will be adapted to Indian conditions. The Bureau will be expected to develop close collaboration with a number of different institutions in India and abroad for research programmes of this kind.

## SUMMARY

The first plant genetic resources were identified nearly ten thousand years ago in the valleys of Euphrates and Tigris when man started to domesticate crop plants. Following this early beginning, there has been an enormous development of genetic diversity of crop plants as seeds and planting materials were moved to different parts of the world and selections were made by generations of farmers in response to local environments and preferences, producing in this way a large number of landraces. This golden age of the expansion of plant genetic diversity came to an end with the advent of scientific plant breeding in the early years of this century, with improved crop varieties replacing the

traditional cultivars. The last 25 years in particular have seen a massive replacement of local varieties and landraces of crop plants, especially those of major cereal grains like wheat, rice and maize, by a limited number of high yielding varieties.

Many of these modern varieties evolved at the International Agricultural Research Centres for wide adaptation have made a significant contribution to world agriculture, but at the same time, they have presented a major threat to the world's plant genetic resources. Fortunately, a coordinated and concerted response by the national agricultural research systems working in close collaboration with international organisations like the International Board for Plant Genetic Resources located in the FAO has helped to avert this threat and a large part of the genetic variability found in traditional agriculture has been collected and conserved in gene banks, many of which are now located in the developing countries.

The threat today is of a different kind. It is the increasing genetic uniformity of world agriculture which is now being built up around high yielding varieties with a narrow genetic base. This threat can be best met by decentralizing and diversifying the high yielding varieties development programmes so that the responsibility for the evolution of new varieties is increasingly passed on to the national agricultural research systems. The International Agricultural Research Centres would now be providing support of a different kind—helping to collect, conserve and evaluate genetic resources; organizing research programmes for the development of transgenic varieties using techniques of genetic engineering and making it possible to overcome the emerging yield ceilings in some of our major food crops. The decentralized breeding programmes should help to inject into world agriculture a wide range of genetically diverse varieties constituting a multilineal complex and erecting genetic barriers against the build-up and spread of pests and pathogens.

It took ten thousand years to develop world agriculture to its present stage of productivity on the basis of free movement and exchange of plant genetic resources. Future progress in this regard may be seriously undermined with the introduction of a patent regime for seeds of new crop varieties developed through the recombinant DNA technology. This will be unfortunate because the short-term gains made possible by such patents do not justify the abandoning of the concept of plant genetic resources as a common heritage of mankind—a concept which has served world agriculture so well.

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