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Editorial

The Contribution of Professor Gian Tommasso Scarascia Mugnozza to the Conservation and Sustainable Use of Biodiversity

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Abstract: During his lifetime, Professor Scarascia Mugnozza contributed significantly to the field of population genetics, his research ranging from wheat breeding in arid and semi-arid regions, to the conservation of forest ecosystems. He promoted regional networks across the Mediterranean, linking science and policy at national and international levels, focusing on the conservation and sustainable use of genetic diversity. In addition, he worked intensely on improvement of knowledge bases, raising awareness on how research could inform international agreements, and thus lead to evidence-based policies. The loss of biodiversity and the resulting implications for environmental, socio-economic, political, and ethical management of plant genetic resources were of major concern, and he highlighted the absolute necessity for conservation of genetic diversity, stressing the importance of building positive feedback linkages among ex situ, in situ, on-farm conservation strategies, and participatory approaches at the community level. His work emphasized the importance of access to diverse plant genetic resources by researchers and farmers, and promoted equitable access to genetic resources through international frameworks. Farmers' rights, especially those in centres of origin and diversity of cultivated plants, were a key concern for Professor Scarascia Mugnozza, as their access to germplasm needed to be secured as custodians of diversity and the knowledge of how to use these vital resources. Consequently, he promoted the development of North-South cooperation mechanisms and platforms, including technology transfer and the sharing of information of how to maintain and use genetic resources sustainably.

Keywords: biodiversity; germplasm; genetic resources; International Treaty; conservation

1. Introduction

The current president of the Italian Science Academy also called "The Academy of the Forty" declared, during the Scarascia Mugnozza commemoration day, that "*It is difficult to fully remember the work of Gian Tommaso Scarascia Mugnozza, a man of charismatic personality, brilliant intelligence, great culture, with an extraordinary capacity of translate his ideas and intuitions into concrete projects*" [1]. The contribution of Professor Scarascia Mugnozza in promoting plant genetic resources diversity for mitigating and adapting to environmental changes, and its importance in addressing malnutrition and food security, is substantial and should be not be lost in time (see Figure 1 for a timeline highlighting the major developments at international and national levels).

At the 19th McDougall Memorial Lecture (October 1995) at the Food and Agriculture Organization of the United Nations (FAO) in Rome, Professor Scarascia Mugnozza began his speech by asserting "loss of biodiversity is often presented as an ecological problem, but the fundamental underlying causes are socio-economic and political" [2], and it is this that guided his lifetime's work and achievements.

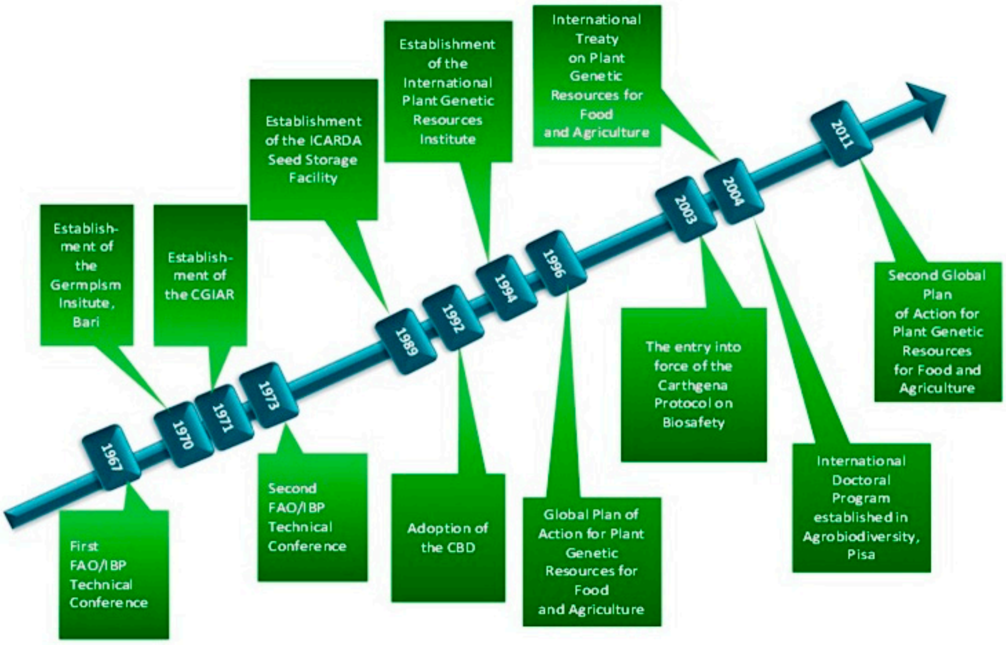

Figure 1. Timeline highlighting the major contributions of Prof. G.T. Scarascia Mugnozza for the conservation and sustainable use of plant diversity.

In this paper, which was published in the Special Issue launched to honour the memory of Professor Gian Tommaso Scarascia Mugnozza, we provide an overview of his work within the national and global technical and policy landscapes of the conservation and use of genetic resources for food and agriculture.

2. Conservation Activities

2.1. Ex Situ Conservation and International Frameworks

In 1945 in Quebec, Canada, the Food and Agriculture Organization of the United Nations (FAO) was founded with initial support from 42 countries, the mandate of which was increased food security through improved agricultural production [3]. In the 1960s, the FAO began to address issues that related not only to production, but also to the conservation of genetic resources. This was addressed at the FAO Technical Conference held in Rome in 1967, three seed banks were proposed for Northern Europe (Sweden), Central Europe (Germany), and for the Mediterranean region. Professor Scaracia Mugnozza, then Professor of Agricultural Genetics at Bari University, proposed that the Committee for Agricultural Sciences of the National Research Council Institute (CNR) establish a national genebank in Bari through the establishment of the Germplasm Institute. He became the first director of the Germplasm Institute and took part in numerous collection missions that were conducted in the 1970s and 1980s by the Institute and FAO [4,5].

2.2. Consultative Group on International Agricultural Research

In 1971, he attended the international meeting in Beltsville, United States of America (USA), which would give rise to the Institutes and Centres of the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is a network of 15 international agricultural research centres, which manages approximately 600,000 agricultural seed samples [6]. It was established in 1971, and launched at the World Bank, with the sponsorship of UNDP, FAO, the World Bank, and an initial group of just over twenty donors. In 1972, Professor Scarascia Mugnozza participated in the Union Nations Conference on Human Environment organized in Stockholm, working out guidelines for safeguarding the genetic resources of plants. Following this development, Scarascia Mugnozza joined the Technical Advisory Committee of CGIAR. Finally, in 1994, most of the crop germplasm that was held in CGIAR genebanks was placed under the auspices of the FAO to be held in trust by the world community (see Figure 2 for the geneflows among the diverse stakeholders in the CGIAR System) [7].

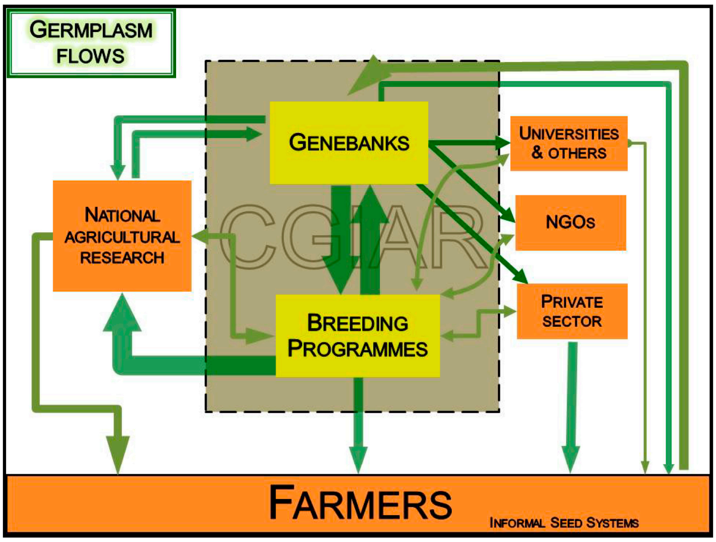

Figure 2. Germplasm flows in and out of the Consultative Group on International Agricultural Research (CGIAR) [7].

Professor Scarascia Mugnozza believed firmly that conservation of germplasm had to be as inclusive as possible. He liaised with prof. M.S. Swaminathan in India and helped to promote community-based conservation approaches, involving programmes for conserving farmers' varieties and landraces, and providing compensation and access to the stored PGR [8]. The "Scarascia Mugnozza Community Genetic Resources Centre", established in Chennai, India, with funding from the Government of Italy (Figure 3), allows for the exchange of genetic resources among farmers and promoting participatory plant breeding [9,10].

Figure 3. Professor Scarascia Mugnozza inaugurating the Community ex situ Genebank of the SMCGRC at MSSRF in Chennai. The picture is taken from the historical archives of the Accademia delle Scienze Detta dei XL (Rome, Italy).

2.2.1. International Plant Genetic Resources Institute

The need for international coordination of conservation of plant genetic resources activities was an area to which Professor Scarascia Mugnozza contributed substantially. In 1974, the International Board for Plant Genetics (IBPGR) was established at FAO in Rome to coordinate an international plant genetic resources program, including emergency collecting missions, and building and expanding national, regional, and international genebanks.

Professor Scarascia Mugnozza was member of the IBPGR Board of Trustees in 1991, when it became the International Plant Genetic Resources Institute (IPGRI) [11]. He assisted in identifying a location in Rome, where IPGRI was established, and, together with other international institutes dealing with agriculture and food, started in 1988. In January 1994, IPGRI began to operate independently as a CGIAR centre, and, at the request of CGIAR, took over the governance and administration of the International Network for the Improvement of Banana and Plantain (INIBAP).

2.2.2. International Centre for Agriculture Research in the Dry Areas

In 1977, CGIAR established the International Centre for Agriculture Research in the Dry Areas (ICARDA) with headquarters in Aleppo in Syria. Professor Scarascia Mugnozza was part of the Board of Trustees for two terms over three years, engaging in delineating research lines and operational aspects. ICARDA works on addressing the needs of resource-poor farmers through research on improving productivity, incomes, and livelihoods, especially in those areas where water is a limiting factor for agricultural production. He oversaw the renovation of an experimental station, which was built by Denmark in the Bekah valley, and its conversion into a seeds storage facility, inaugurated in 1989. The ICARDA Genebank now holds over 135,000 accessions from over 110 countries: traditional varieties, improved germplasm, and wild crop relatives. These include wheat, barley, oats, and other cereals; food legumes, such as faba bean, chickpea, lentil, and field pea; forage crops, rangeland plants, and wild relatives of each of these species.

3. Rolling Global Plan for Plant Genetic Resources for Food and Agriculture

Professor Scarascia Mugnozza participated actively in negotiations that led to the development of the Global Plan of Action for the Conservation and Sustainable Use of Plant Genetic Resources for Food and Agriculture (GPA), adopted in 1996 by 150 countries at the International Technical Conference on Plant Genetic Resources in Leipzig, Germany [12]. The resulting Leipzig Declaration asserted, "Our primary objective must be to enhance world food security through conserving and sustainably using plant genetic resources" [13].

Today, the Second Global Plan of Action for Plant Genetic Resources for Food and Agriculture (Second GPA), which was adopted by the FAO Council on 29 November 2011, updates the GPA [14]. The Second GPA was prepared through a series of regional consultations, with the participation of 131 countries and representatives of the international research community, the private sector and civil society. It plays an important role in the international policy framework for world food security, as a supporting component of the International Treaty for Plant Genetic Resources for Food and Agriculture.

4. International Treaty on Plant Genetic Resources for Food and Agriculture

In his speech, delivered at the 19th McDougall Memorial Lecture in 1995 [2], Professor Scarascia Mugnozza focused on the need to develop an international mechanism to allow for the fair and equitable exchange of Plant Genetic Resources for Food and Agriculture (PGRFA). He followed up on this by contributing to the development of the Madras Declaration, which was undersigned by diverse stakeholders from 76 countries (Figure 4) and was presented at the World Food Summit, November 1996, in Rome [8]. The Declaration highlighted the need for increased investment in agricultural research and rural development in order to guarantee food security and social equity by the establishment of an international fund.

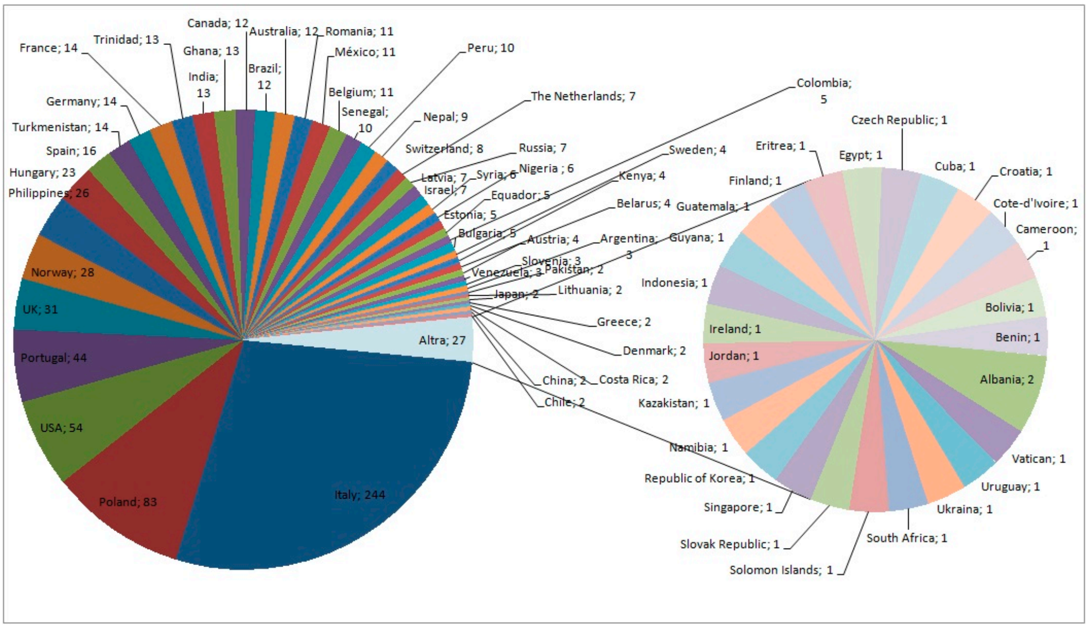

Figure 4. Number of scientists and stakeholders signed the Scarascia-Swaminata petition.

Prior to this, the International Undertaking on Plant Genetic Resources (IUPGR), which was adopted in 1983, was the first and main international instrument addressing the conservation and sustainable use of PGRFA. This was then revised in accordance with the Convention on Biological Diversity (CBD), which entered into force in 1992 [15]. However, it was not comprehensive and legally binding enough to address the needs highlighted in the Madras Declaration.

In response to the global demand for a more detailed instrument, the International Treaty for Plant Genetic Resources (the Treaty) was developed and adopted at the Thirty-first Session of the FAO Conference 2001 in Rome. Professor Scarascia Mugnozza collaborated extensively with the Treaty Secretariat to promote the linkages between research and the contribution of agricultural biodiversity to food and nutrition security and to sustainable agriculture.

The Treaty entered into force 90 days after 40 signatory States ratified it on 29 June 2004 [16]. In accordance with the Convention on Biological Diversity (CBD), the Treaty established a Multilateral System (MLS) of access and benefit-sharing for the most important crops for agriculture (64 crops, representing 52 genera and 29 forage genera), listed Annex 1 of the Treaty, to address the interdependency of countries for access to germplasm (www.planttreaty.org). Thus, contracting parties are obliged to provide access to PGRFA listed under the MLS when requested to do so by another Party (or a legal or natural person under the jurisdiction of a Party, or by an international institute that has signed an agreement with the governing body). Contracting Parties are also obliged to provide access when such PGRFA has been acquired under these same terms [17]. The scope of the Treaty, including its articles on conservation and sustainable use, is all PGRFA, while the MLS is specific to the crops listed under Annex 1 of the Treaty.

5. In Situ Conservation of Natural Ecosystems and Biodiversity

Professor Scarascia Mugnozza played a key role in ecosystem management at the national level, developing a set of tools to monitor biodiversity and ecosystem management. The 1970s and 1980s were decades where public awareness drove adaptation and mitigation strategies in research to address air and water pollution that threatened the survival of forest ecosystems. Hundreds of thousands of acres of woodlands in Scandinavia, Poland, Germany, France, and Switzerland, showed severe symptoms of defoliation due to the phenomenon of acid rain. This was also seen in areas of Italy, which, in addition to being severely affected by pollutions, was compounded by coastal erosion due to deforestation.

Professor Scarascia Mugnaozza coordinated case studies that were undertaken carried out in two locations: the 6000 ha forests of San Rossore, Tuscany (Italy), and those of Castelporziano, close to Rome. These lands had been managed at low levels of intensity and intervention, having been used traditionally for activities, such as hunting, firewood, and the breeding of local equine and bovine breeds [18]. He headed a commission to study the degradation of San Rossore's vegetation, and, in 1993, was appointed to chair the Technical Scientific Commission for monitoring the Castelporziano estate.

In collaboration with researchers from diverse disciplines, he set up a Territorial Information System consisting of seven working groups for collecting data on the atmosphere, soil, hydrogeology, vegetation, fauna, and anthropogenic impacts. This resulted in the review of those criteria that had inspired the guidelines of previous activities, and established, among other things, changes in the management of woodlands with a view to promote natural forest regeneration and conserve the biodiversity that was present within those ecosystems. In accordance with the European Community Action Plan (Mediterranean Action Plan), the San Rossore and Castelporziano estates are now used for environmental research, and to assess the impacts of different woodland management regimes, with the goal to upscale the sustainable management of forests to other areas.

6. Biotechnology Role in the Conservation of Biodiversity and Sustainable Production Systems

Professor Scarascia Mugnozza was at the forefront of promoting new technologies that were addressing development in the sustainable use of genetic resources. As a member of the Italian delegation, in 1955 he participated in the Conference of Geneva on the 'Peaceful Uses of Atomic Energy'. Scarascia Mugnozza established contacts with the delegates of American Atomic Commission during the conference and obtained, under "Atoms for Peace", a cobalt reactor. This was used for the irradiation of plants and seeds in so-called 'gamma fields' in a continuous manner (Figure 5). This inspired him to set up the Farm Laboratory at the Centro Casaccia of the National Centre for Nuclear Energy (CNEN), established in 1960 near Rome [10]. One of his most important contributions was as the scientific secretary of the advisory commission in 1961, and the 'Plant Genetics' Laboratory became the 'Laboratory for Nuclear Applications in Agriculture' under his guidance. Scarascia Mugnozza identified four research lines of interest for Italian research in agriculture, and this led to the development of the following fields of research in the Domestic Radiation Applications Laboratory:

1. the induction of mutations in improving agricultural crops;
2. a new means of biological control: the technique of sterilizing insects with gamma irradiation;
3. the application of the radioisotopes method to the study of soil-fertilizer-plant relations;
4. the irradiation of foods in order to ensure their preservation [19].

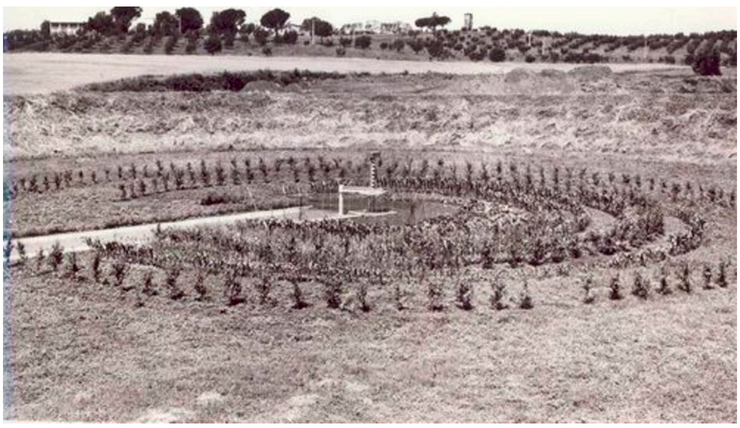

Figure 5. "Gamma fields" at the National Centre for Nuclear Energy (CNEN) in 1962.

The laboratory results were in the fields of:

- Applied mutagenesis to the improvement of agrarian plants.

The objective was to use mutagenesis to induce genetic variability useful for the improvement of autogamous plants (cereals, horticultural), and to increase the frequency of somatic mutations in vegetative propagation plants (fruit trees and flowering plants). Several crop varieties were produced with significant reduced plant height, including the durum wheat varieties Castelfusano and Castelporziano that were selected from Cappelli mutants (Figure 6). The variety, Creso, registered in 1974, was the major variety used in Italian agriculture, and, in 1984, was the seed certified variety that was used in more than 60% of the field and more than 25% of the overall durum wheat area (certified and uncertified seeds) with an utilization on more than 400,000 ha in 1982. Moreover, its cultivation was present over more than 30 years. Several other important varieties have been created utilizing Creso in their pedigree.

- The sterile insect larvae technique for the fruit fly (*Ceratitis capitata*).

Male insects were sterilized by radiation and released to the environment. Being sterile, the insect population was drastically reduced without any environmental impact. The diffusion of sterile insects were first trialled on island environments before being used on the Italian mainland.

- Technique of radioisotopes (N, P, K) used as tracers for the study of physiology and nutrition of plants.
- Preserving foodstuffs for the extension of market life, particularly fruit and vegetables, and the preservation of grain and other agricultural products, such as: potatoes, onions, strawberries, oranges, grapes, and in radio-disinfestation of dried figs and packs of flowers (carnations).

Figure 6. Professor Scarascia Mugnozza (right) demonstrating Durum wheat mutant lines with agronomic value. The picture is taken from the historical archives of the Accademia delle Scienze Detta dei XL (Rome, Italy).

Professor Scarascia Mugnozza also promoted the use of biotechnology for human benefit [20,21]. In 2001, as the president of a commission of scientists, he sought to clarify the scientific basis of the potential and impact of plant biotechnologies. This commission described how, instead of relying on random recombination between a large number of genes by conventional crossing of plants (including different species), the molecular method allows for the inclusion of sequences of DNA carrying specific characters in the genetic information of an organism (genome), creating a transgenic organism, also known as Genetically Modified Organism (GMO) or Living Modified Organism (LMO). This can reduce the timing of selection, preserve beneficial characteristics of the original genotype, and add individual genes where genotypes are deficient, thus making it possible to precisely and minimally alter the genome. The method also allows for the exchange of genes between sexually incompatible organisms, thus drastically increasing the potential of using natural biological diversity.

His approach was that rather than cultivating new land, thereby destroying forests, biodiversity, and other elements of possible climate change mitigation, it was possible to decrease impacts on natural ecosystems, while increasing the productivity of existing agro-ecosystems. Additionally, the careful use of biotechnology, and, in particular, genetic engineering, could contribute to innovative processes allowing the development of new, more resilient and productive crop varieties, while decreasing the levels of inputs that are needed (pesticides, fertilizers, herbicides). Nevertheless, the use of new varieties may also pose risks. Thus, both transgenic and conventional varieties should be subjected to risk analysis, and transgenics accepted when, in relation to expected benefits, they are less dangerous than those that are obtained by conventional techniques. The Cartagena Protocol on Biosafety (entered into force in 2003) defines a LMO as "any living organism that possesses a novel combination of genetic material, obtained through the use of modern biotechnology". Policies have been put into force to safeguard natural systems from potential environmental risks from such LMOs. The Protocol established that an advance informed agreement (AIA), would ensure that countries be provided with the documentation necessary to make informed decisions before agreeing to imports and agricultural production. The Protocol recommends a precautionary approach, and is based on Principle 15 of the Rio Declaration on Environment and Development.

He was recognized as an authority on biotechnology, and was requested to contribute an article to the prestigious Italian Enciclopedia Treccani [22], and in 2004, he received an honorary degree in biotechnology from the University of Naples for his position and activities on the role of biotechnology highlighted in the paper of Scarascia Mugnozza and De Pace [23].

7. Building Upon Global Frameworks of PGRFA

In order to enlarge the research of conservation and evaluation of different genetic resources, Professor Scarascia Mugnozza founded the International Doctoral Program in Agrobiodiversity, established in 2004 at the Scuola Superiore Sant'Anna of Pisa. The first of its kind, it attests to Scarascia's commitment to the training of young people, in particular from developing countries. The school received initial contributions from the Italian government. The course aims to promote scientific and policy research in the field of genetic diversity of agricultural and forestry plants, fostering sustainable agricultural practices to address issues of food insecurity and malnutrition.

In response to the high rates of genetic erosion created by the rapid loss of crop diversity, and by its consequences on agricultural growth and food security, all the activities and institutions he participated in emphasized the very close relationship between technological advancement and basic research, and the economic and social problems that are posed by disadvantaged areas. This distinguished gentleman passed away on 28 February 2011 at the age of 85, and will be remembered as a world authority on plant genetics, and a strong supporter of the scientific community's role in the conservation of biodiversity.

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