RETROSPECTIVE

M. S. Swaminathan (1925–2023)

Architect of India's green revolution

By **Sameen Ahmed Khan**[1] *and* **Sanjay Vasant Deshmukh**[2]

Monkombu Sambasivan Swaminathan, the plant geneticist whose work catalyzed India's agricultural renaissance, died on 28 September. He was 98. Swaminathan worked tirelessly to revolutionize agriculture and ensure food security and sustainable resource management. He aimed to improve crop yields, promote ecological and economic sustainability, and empower small farmers while integrating cutting-edge technology and promoting gender equality in agriculture. Swaminathan's relentless research and advocacy enabled an enduring green revolution.

Born in Kumbakonam, Tamil Nadu, India, on 7 August 1925, Swaminathan received a BSc in zoology from the University of Travancore (now the University of Kerala) in Kerala, India, in 1944, and a BSc in agriculture from the University of Madras in Chennai, India, in 1947. After brief fellowships in New Delhi and Wageningen, Netherlands, he received a PhD from the School of Agriculture at the University of Cambridge in 1952. Swaminathan studied cytogenetics and potato breeding at the University of Wisconsin–Madison for a year. He then returned to India and joined the indica-japonica rice hybridization program at the Central Rice Research Institute in Cuttack. Later in his career, and after his retirement in 1988, he held numerous leadership, consultant, and government positions in India and abroad.

In 1950, Swaminathan began working toward his vision of food security by standardizing techniques that allowed the breeding of previously infertile hybrid plants, thereby setting the stage for sustainable crops. Soon, he had created a potato hybrid that included alien genes conferring resistance to frost. Next, he pioneered efforts to improve the yields of fragile indica rice varieties by crossing them with hardier japonica varieties.

In 1958, Swaminathan offered insights into how to induce mutations in wheat and rice, expediting the development of desired traits. This work led to a better understanding of the effects of food irradiation, a process that uses ionizing radiation to enhance food safety without altering yield. Swaminathan also unraveled the genetic relationships among wheat species, and in 1963, he initiated a breeding program that incorporated dwarfing genes into wheat, producing shorter, stronger plants that boosted yields. A rice breeding initiative followed, in which Swaminathan created basmati strains that stood tall without breaking, even when bearing heavy grains. The release of Pusa Basmati 1121, a rice hybrid with this trait, ensured high yield and quality in basmati rice production, a revolution for food security and farmers.

The green revolution in the late 1960s, made possible by Swaminathan's work, transformed agriculture by introducing high-yield crop varieties and modern techniques. These advances in breeding included "crop cafeterias," in which diverse crop varieties were grown together, offering a balanced diet and improved nutrition, reducing the risk of dietary deficiencies. Instead of using fixed crop schedules, farmers could use crop distribution agronomy, an approach that allows midseason adjustments in crop selection and planting, to optimize yield and food quality.

Swaminathan's creative approach extended into the digital era. In 1997, he established the first computer-aided rural knowledge centers, which promoted agricultural innovation and knowledge dissemination. He understood that digital technology had the power to advance rural prosperity.

Swaminathan chaired the UN's Advisory Committee (now Commission) on Science and Technology for Development from 1981 to 1984, served as director of the International Rice Research Institute from 1982 to 1[illegible] and presided over the International Union for Conservation of Nature from 1984 to 1990. He held advisory roles in the Indian government, led the Indian Council of Agricultural Research from 1972 to 1979, and served as a member of the Indian Parliament's upper house, the Rajya Sabha, from 2007 to 2013.

Awards recognizing Swaminathan's work include 85 honorary doctorates, the Mendel Memorial Medal in 1965, the Ramon Magsaysay Award in 1971, and the prestigious Padma Shri in 1967, Padma Bhushan in 1972, and Padma Vibhushan in 1989. In 1986, he received the Albert Einstein World Award of Science, and in 1987, he was the inaugural laureate of the World Food Prize, often considered to be an agricultural Nobel Prize.

Author S.V.D. first met Swaminathan in 1988 and assisted him in establishing the M. S. Swaminathan Research Foundation (MSSRF) in Chennai, India. The foundation's mission is to harness science and technology for sustainable agricultural and rural development. They collaboratively devised an innovative global "hotspot" strategy for preserving the genetic resources of mangrove forests worldwide, garnering more than $500 million in funding over a span of three decades. Between 1991 and 1997, author S.A.K. frequently met with Swaminathan as a PhD scholar from the Institute of Mathematical Sciences, an institution neighboring MSSRF.

Swaminathan's wisdom transcended academia. He understood the intricate interplay between science and society. His commitment to translating knowledge into tangible solutions was exemplified by his initiation of community-based gene, seed, and grain management strategies in 1998, which involved local participation and sustainable practices to ensure food security. He also engaged with critics and the movement protesting genetically modified organisms by advocating for a balanced approach to biotechnology and emphasizing safety and ethical considerations. Seamlessly blending vision and pragmatism, Swaminathan created disaster management strategies and developed a scientific monsoon management plan in 1979, one of many examples of his proactive approach to addressing pressing challenges.

At the core of Swaminathan's character was a profound sense of compassion. He championed technology development strategies that embodied empathy and an unwavering commitment to comprehensive progress, particularly for impoverished and food-insecure people, especially women. He recognized that genuine advancement encompassed not only science and technology but also the well-being of all, marginalized communities included. ■

10.1126/science.adl3574

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Science **382** (6673), . DOI: 10.1126/science.adl3574