

# Transforming Drylands: ICRISAT's Five Decades of Innovation in Chickpea and Pigeonpea Research

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*Speed Breeding Pigeonpea at ICRISAT* *Speed Breeding Chickpea at ICRISAT*

Drylands hold immense potential for sustainable food production, providing a viable opportunity to combat desertification, expand arable land and meet the ever-growing global demand for food. Essential to this transformative journey are dryland food legumes, like chickpea and pigeonpea. These resilient pulses breathe life into barren landscapes, fostering fertile grounds and ensuring not only the nutritional well-being but also the economic stability of dryland communities.

Specializing in dryland agriculture, ICRISAT boasts over five decades of expertise in millet, legume and oilseed research—with chickpea and pigeonpea among its speciality crops. From meticulously preserving genetic diversity to implementing innovative technologies, ICRISAT delivers a comprehensive suite of solutions and practices tailored to the unique needs of the more than 2.1 billion people who inhabit drylands of Asia, Africa and beyond.

## 1. Leading Genetic Resource Preservation and Utilization for Enhanced Crop Breeding

### 1.1. The ICRISAT Genebank: A Global Repository

The ICRISAT genebank, established in 1979 in

Patancheru, India, serves as a global repository for the collection of germplasm for chickpea and pigeonpea, alongside millets and groundnut. As of December 2023, the ICRISAT genebank conserves 20,838 chickpea germplasms originating from 61 countries and 13,559 pigeonpea germplasms originating from 72 countries. Being a signatory to the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), the ICRISAT genebank is committed to ensuring unrestricted access to these germplasms for research purposes. Accordingly, it has distributed over 647,600 chickpea and pigeonpea samples to researchers from over 130 countries.

### 1.2. Advancements in Genomic Research

ICRISAT led the first chickpea genome sequencing in 2013, a foundational resource for further research. In 2021, ICRISAT spearheaded one of the most extensive pan-genome assembly projects for chickpea, engaging an international consortium of researchers from 41 different organizations. This collaborative effort resulted in the sequencing of 3,366 chickpea lines from 60 countries, comprising 3,171 cultivated varieties and 195 wild types preserved across various genebanks.

In the case of pigeonpea, ICRISAT directed a sequencing project in 2011 that focused on 12 pigeonpea genotypes. A follow-up resequencing project in 2017, conducted by a global team of 19 scientists from 9 institutes and led by ICRISAT, re-sequenced the genomes of 292 pigeonpea varieties sourced from 23 countries.

These genomic endeavors offer a powerful tool to explore and utilize genetic diversity, aiming to improve



crucial traits such as yield, quality, disease resistance, and tolerance to heat and drought conditions.



*Chickpea scientists and breeders gathered at ICRISAT in January 2024 for Scientist's Field Day Photo: ICRISAT*

### 1.3. Revolutionizing Breeding with Rapid Genetic Advancements

Supported by the CGIAR Research Program on Grain Legumes and Dryland Cereals (CRP-GLDC) along with numerous industry collaborators, ICRISAT launched an initiative focused on rapid genetic advancement in 2020. This initiative aims to streamline the breeding process, significantly reducing the time, cost, and effort required to develop new crop varieties.

The research team introduced a groundbreaking open-access speed breeding protocol for chickpea in 2019, followed by a similar protocol for pigeonpea in March 2024. These advancements have dramatically shortened the breeding cycle, cutting down the typical development time for new chickpea varieties from 12 years to just 6-7 years, and for pigeonpea varieties from 7 years to a mere 2-4 years. By making these protocols available openly, ICRISAT is driving the faster development of superior crop varieties.

### 1.4. Hybrid Parents Research Consortium

ICRISAT's Hybrid Parent Research Consortium (HPRC) model is designed to foster public-private partnerships and encourage private-sector investment in the enhancement, research, and development of crops, particularly those amenable to hybridization.

Drawing inspiration from the success of the HPRC model in sorghum and pearl millet, similar initiative was

introduced for pigeonpea in 2004. This collaborative model promotes rapid advancement in the development of pigeonpea hybrid varieties and enhances the sector's capacity for innovation. The progress achieved through this initiative is poised to uplift farmers' livelihoods and bolster food security by bringing superior pigeonpea varieties to the field.

## 2. Delivering Impact: Enhancements in Food and Nutrition Security



*Tribal women farmer from Telangana in Pigeonpea Field*

ICRISAT collaborates with various National Agricultural Research Systems (NARS) to introduce new and improved legume varieties, significantly enhancing food security and nutrition. By December 2023, ICRISAT had facilitated the release of 189 chickpea varieties across 28 countries and 124 pigeonpea varieties in 20 countries.

In a succession of groundbreaking accomplishments, ICRISAT successfully introduced unique legume varieties to agriculture, benefiting farmers and setting new precedents in crop development.

The ICAR-ICRISAT partnership has been involved in improving chickpea productivity and resilience in India. High-yielding and stress-tolerant varieties have driven remarkable growth in central India from 2.33 to 4.18 million tons between 1998/99 and 2021/22, representing a 1.8-fold increase in production. The impact has been even more pronounced in southern India, where the ICAR and ICRISAT partnership varieties dominate 80% of the chickpea area, resulting in a





staggering 2.4-fold production surge from 2.03 to 5.18 million tons during the same period.

Landmark varieties like ICCV 92944 (JG 14) renowned for drought tolerance and fusarium wilt resistance, have significantly contributed to enhancing chickpea's resilience and ensuring food security for smallholder farmers. Chickpea varieties developed through ICAR-ICRISAT collaborations accounted for 65% of the total indent of chickpea breeder seed in Central and South India.

Another landmark achievement of this partnership is the development of early-maturing chickpea varieties suitable for the semi-arid climates of southern India. From 1981 to 2018, chickpea production increased 6 times (+7.0 million tons) in Central and South India due to a 3-times (+5.4 million hectares) increase in area and a doubling of productivity. In 2018, 48% of global chickpea production and 73% of Indian chickpea production came from central and southern India.

In response to labor shortages in agriculture, particularly in harvesting and threshing, the Phule Vikram variety was developed with Mahatma Phule Krishi Vidyapeeth and released in Maharashtra in 2017, and subsequently released in central India. This initiative, funded by the Government of India, also led to the development of three additional high-yielding, machine-harvestable chickpea varieties.

Similarly, in pigeonpea, the ICAR-ICRISAT partnership was initially focused on the development of stable sources of resistance for wilt and Sterility Mosaic Diseases (SMD), which are highly devastating and endemic in India. Since 2000, concerted efforts have been made in CGMS-based (Cytoplasmic Genetic Male Sterility) hybrid development. ICRISAT developed varieties viz., ICPL 99050, ICPL 14003, ICPH 3762, and ICPL 88039, which are released by ICAR and NARS partners and are widely popular among all the states of India. ICP 8863 (Maruti), the first wilt-resistant variety, stabilized the livelihoods of farmers in central and southern zones. ICPL 87119 (Asha), a wilt and SMD-resistant variety, is also another widely

popular variety. In 1991, ICRISAT released the world's first GMS-based hybrid, ICPH 8. To make hybrid technology commercially viable, a stable CGMS system was developed in the crop, and this was followed by the development of an economical hybrid seed production technology.

So far, ICRISAT, in collaboration with the National Food Security Mission of India, the Indian Council of Agricultural Research, and State Agricultural Universities, has released hybrids ICPH 2671 and ICPH 2740 for cultivation in India. These hybrids have recorded 30 to 40% yield advantage over varieties in farmers' fields.

### 3. Shaping the Future: Strategic Breeding for Market Needs



*Chickpea field photograph exhibiting different maturity groups*  
ICRISAT's breeding programs are tuned to market demands, focusing on developing chickpea and pigeonpea varieties that cater to specific consumer and climatic needs. ICRISAT's pigeonpea breeding program focuses on four key market segments, emphasizing climate resilience and pest and disease resistance across various maturation periods. ICRISAT, in collaboration with the Indian Institute of Pulses Research (IIPR) - Kanpur and twelve State Agricultural Universities has been disseminating high-yielding, early maturing pigeonpea varieties and hybrids in the states of Telangana, Andhra Pradesh, Karnataka, Maharashtra, Madhya Pradesh, Jharkhand, Chhattisgarh, Rajasthan, Bihar, Uttar Pradesh, Punjab, and Haryana

Similarly, for chickpea, ICRISAT is working on two primary market segments: 1. Desi chickpea, aimed at a broad range of food applications including flour and snacks, where traits like maturity duration, yield, disease



resistance, heat tolerance, and seed characteristics are key; and 2. Kabuli chickpea, preferred for their aesthetic appeal in salads, hummus, and more, with focus on similar traits enhanced for market-specific demands.

This strategic alignment with market needs and consumer preferences underpins ICRISAT's mission to develop versatile, high-performing legume varieties that bolster food security, meet market demand, and promote sustainable agricultural practices.

#### 4. Charting the Course for the Next 50 Years



*Pigeonpea in Rice Fallows*

As ICRISAT embarks on its next 50-year journey, the institute stands poised to further impact agricultural science, with a particular focus on chickpea and pigeonpea research. This period will build upon a solid foundation of half a century's work that has significantly impacted dryland agriculture worldwide. Through groundbreaking research and development, ICRISAT is committed to enhancing food and nutrition security, advocating for sustainable farming practices, and contributing to the economic prosperity of the most vulnerable communities. This next phase in ICRISAT's history is not just about continuing the legacy but charting a new course that addresses the evolving challenges of agriculture, climate change, and food security.

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