

Hybrid Pigeonpea (Pushkal)

World's first cytoplasmic male sterility based legume



INTERNATIONAL CROPS RESEARCH INSTITUTE FOR THE SEMI-ARID TROPICS
Science with a human face

Red gram or pigeonpea [*Cajanus cajan* (L.) Millsp.] is an important food legume that is grown on about 5 million ha of rainfed semi-arid tropical areas of Asia, Africa and the Caribbean. In India it is grown on about 3.58 million ha. Besides India, Myanmar (560,000 ha), China (150,000 ha) and Nepal (over 20,000 ha) are other Asian countries where pigeonpea is cultivated. In Africa, Kenya, Malawi, Mozambique, Tanzania and Uganda produce considerable amounts of pigeonpea. It is also cultivated in the Caribbean Islands and some South American countries.

In India, de-hulled split cotyledons of pigeonpea are cooked to make dal (thick spicy soup), which is eaten with bread and rice, while in southern and eastern Africa and South America, whole seeds (both dry and immature) are used as a nutritious vegetable. Farmers use its broken seeds, husks and pod walls as feed for cattle, while the dry stems are used as firewood and to reinforce the mud walls of huts.

Pigeonpea is a very suitable crop for rainfed agriculture because it is drought tolerant, needs minimum inputs and produces reasonable yields even



Farmers measuring the bountiful harvest of the Pushkal.



ICRISAT scientists and China partners in a hybrid seed production field in Yuanmou, China.

under unfavorable agro-ecological conditions. Its seeds contain about 20-22% protein and reasonable amounts of essential amino acids. Its drought resistance, high protein content and multiple uses make it an ideal crop for smallholder farmers.

Over the past 50 years, pigeonpea productivity has remained low (700 kg ha⁻¹) in spite of several new varieties being released, and the global production (3.5 m t) always falls short of ever-rising demand. To achieve a breakthrough in yield, ICRISAT developed an innovative breeding technology to develop commercial hybrids of this crop, the first such attempt in any food legume. ICRISAT is working with the Indian Council of Agricultural Research (ICAR), state agricultural universities, seed corporations and private seed companies in this effort.

Unlike other pulses, pigeonpea is a partially out-crossed species. To increase its yield potential, ICRISAT scientists made use of its out-breeding nature to develop a hybrid breeding technology.

GMS-based hybrids

The world's first pigeonpea hybrid, ICPH 8, based on the genetic-male sterility (GMS) system, was released in 1991 by ICRISAT and ICAR. This is considered a milestone in the history of food legume breeding. Subsequently, five other GMS-based hybrids were released by various ICAR institutions.

In spite of demonstrating high yields, these hybrids could not reach farmers' fields because of their high costs and quality concerns. The inherent constraints were associated with the seed multiplication of their female parents, and this was a major bottleneck in large scale hybrid seed production.

CMS-based hybrids

The GMS experience led scientists to develop hybrids based on the cytoplasmic nuclear male



The world's first pigeonpea hybrid, ICPH 8.

sterility (CMS) system – the most widely accepted means of producing commercial hybrids in a number of field crops. The expression of CMS, in part, is controlled by a genetic factor carried only through the female parent, which is never lost or diluted in succeeding generations of reproduction. This cytoplasmic factor is referred to as 'N' for normal male-fertile cytoplasm and 'S' for the male-sterile cytoplasm. The male-sterile female (A-line) lines are maintained by these two important cytoplasmic factors.

The first breakthrough in this technology was achieved when a CMS system was developed by crossing *C. cajanifolius* (a wild species) and a cultivated line. This CMS system is stable across diverse environments and has an excellent fertility restoration system.

After the development of a stable CMS system, several experimental hybrids were produced and evaluated. Kandalkar (2007) found that CMS-based hybrids recorded standard heterosis up to 156% for grain yield whereas Saxena (2007) reported yield advantage of 50 to 100% over the popular varieties/checks.

In multi-location trials conducted at 7 locations, several hybrids recorded significantly higher yields than the control. Similarly, in the medium duration hybrid trials conducted at 11 locations in 2007, ICPH 3341 recorded 35% higher yield than Maruti, the best control variety.

ICPH 2671

The new hybrids developed on an improved A-line (ICPA 2043) showed promise with respect to yield, seed size and disease resistance. Among medium duration hybrids ICPH 2671, which matured in 170-180 days, produced 41.6% greater yield than control Maruti in 21 trials conducted from 2005 to 2007. This hybrid also has large attractive seeds and greater plant height. It is highly resistant to wilt and sterility mosaic diseases, a primary need of the medium maturity group.

Pigeonpea hybrids are usually characterized by increased plant vigor and reduced seed rates, greater drought tolerance, greater disease resistance and greater adaptability, but in 29 on-farm trials conducted during 2007, ICPH 2671 (1783 kg ha⁻¹) recorded 28.5% higher yield over Maruti (1388 kg ha⁻¹).

Partnership with the private sector

The partnership between ICRISAT and the private sector has evolved over time. In the early years, ICRISAT played a nurturing role to the fledgling industry through informal networks. Recent years have witnessed remarkable growth in the private sector investments in research and development in crop improvement, especially in crops that provide hybrid cultivar options.

The Hybrid Parents Research Consortia (HPRC) is a joint initiative of ICRISAT and the private sector that was formed with the objective of increasing poor farmers' access to better hybrids. The consortia deals with diversification of CMS systems, development of high yielding, disease and pest resistant hybrid parents, and training for transfer of hybrid seed production technology.

The private sector has become a major channel for delivering high yielding hybrids and parents developed from ICRISAT-bred parent materials to farmers. As a research partner, the private seed sector is a source of funds and complementary expertise, especially in the area of development and marketing of hybrid seed.



ICRISAT Director General Dar and Chairman of Pravardhan Seeds at the release function.

ICPH 2671 was selected for commercialization by Pravardhan Seeds (P) Ltd., a member of the HPRC and named Pushkal (which means bountiful in Sanskrit). Pravardhan Seeds, along with ICRISAT started production of ICPH 2671 during the kharif season of 2007. A limited quantity of F1 seed was produced and this has been distributed for test marketing in 6 districts of Andhra Pradesh and 3 districts of Maharashtra during kharif 2008.

Pushkal was released for commercial production in July 2008.

Potential of pigeonpea hybrids under changing climate

Climate change is expected to have a strong negative impact on productivity of crops as well as livestock, thereby undermining the long-term sustainability of already fragile dryland environments. In these conditions, pigeonpea hybrids may prove to be a boon because the hybrids have a speedy growth rate, greater root and shoot biomass, and greater resilience to combat drought, salinity and diseases. Under changed

climatic conditions, a healthy hybrid crop will not only provide nutritive food and fodder but also improve soil fertility and structure.

Strategies for future research

Some of the challenges that need to be addressed to implement dynamic hybrid pigeonpea programs include: diversification of hybrid parents to develop high yielding hybrids for specific agro-ecological regions to suit local environment and market needs; incorporation of stable sources of resistance to major diseases and insects; fine-tuning hybrid seed production technology to optimize efficiency and returns; involving more state agricultural universities and public and private seed companies to spread the technology more widely among farmers; organized capacity building of partners in various aspects of hybrid breeding; development of parameters to maintain hybrid seed quality; conduct basic breeding and agronomy research for increased productivity; use biotechnological tools to enhance the efficiency of hybrid parent breeding; and information sharing using latest technologies.

About ICRISAT



Science with a human face

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 644 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Centers of the Consultative Group on International Agricultural Research (CGIAR).

Company Information

ICRISAT-Patancheru (Headquarters)

Patancheru 502 324
Andhra Pradesh, India
Tel +91 40 30713071
Fax +91 40 30713074
icrisat@cgiar.org

ICRISAT-Bamako

BP 320
Bamako, Mali
Tel +223 20 223375
Fax +223 20 228683
icrisat-w-mali@cgiar.org

ICRISAT-Liaison Office

CG Centers Block
NASC Complex
Dev Prakash Shastri Marg
New Delhi 110 012, India
Tel +91 11 32472306 to 08
Fax +91 11 25841294

ICRISAT-Bulawayo

Matopos Research Station
PO Box 776,
Bulawayo, Zimbabwe
Tel +263 83 8311 to 15
Fax +263 83 8253/8307
icrisatzw@cgiar.org

ICRISAT-Nairobi (Regional hub ESA)

PO Box 39063, Nairobi, Kenya
Tel +254 20 7224550
Fax +254 20 7224001
icrisat-nairobi@cgiar.org

ICRISAT-Lilongwe

Chitedze Agricultural Research Station
PO Box 1096
Lilongwe, Malawi
Tel +265 1 707297/071/067/057
Fax +265 1 707298
icrisat-malawi@cgiar.org

ICRISAT-Niamey (Regional hub WCA)

BP 12404, Niamey, Niger (Via Paris)
Tel +227 20722529, 20722725
Fax +227 20734329
icrisatnc@cgiar.org

ICRISAT-Maputo

c/o IIAM, Av. das FPLM No 2698
Caixa Postal 1906
Maputo, Mozambique
Tel +258 21 461657
Fax +258 21 461581
icrisatmoz@panintra.com

www.icrisat.org