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Indian rice varieties released in countries around the world

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In India, rice is grown under diverse ecosystems as rainfed uplands, rainfed shallow, semideep and deepwater lowlands, irrigated lands and hills. These are the major rice ecosystems found the world over. The model cooperative all-India coordinated rice-testing programme evolved at Hyderabad during 1965 helped the country to reach and sustain self-sufficiency in rice from 1977. The International Rice Research Institute at the Philippines built a global rice-testing programme in 1975 based on the successful AICRIP model. Other countries have also benefited through release and commercial exploitation of India-bred rice varieties.

IN India rice is cultivated in 42 million hectares (mha) under four major ecosystems, viz. irrigated (19 mha), rainfed lowland (14 mha), flood prone (3 mha) and rainfed upland (6 mha) ecosystems. Rice ecosystems in India represent 24% of irrigated areas, 34% of rainfed lowlands, 26% of flood-prone areas and 37% of rainfed uplands cultivated to rice in the entire world[1]. No other country in the world has such diversity in rice ecosystems. Therefore, Indian rice research programme is the principal moving force in the world.

All-India Coordinated Rice Improvement Project (AICRIP)[2] was started in 1965 at Hyderabad under Indian Council of Agricultural Research to usher in green revolution. The coordinated variety improvement and testing programme covers 52 cooperating centres in addition to 51 voluntary centres in different agro-climate regions in the country. This programme helps to exchange and evaluate breeding material quickly across the country.

The aim of AICRIP programme is to improve yielding ability, increase efficiency in the use of external inputs and incorporate resistance to biotic and abiotic stresses. The multilocational testing of breeding stock developed at different research centres is organized by AICRIP. The evaluation of genotype x environment interactions in different ecosystems has been the rationale for the multidisciplinary approach to rice improvement research. Depending on genotype sensitivity to photoperiod, three to four years are needed to identify a promising superior genotype based on data from the

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multilocational tests. In the first year, the newly evolved genotypes are tested in replicated local yield trials. The selected breeding lines from these experiments are included in the zonal coordinated trials called initial variety trial (or initial evaluation trial). Simultaneously, these breeding lines are also put to screening nursery tests for identifying their reaction to pests and diseases. The breeding lines that yield consistently well for two years are grouped to form advanced variety trials (or uniform variety trials) and tested for two more seasons. Agronomic data on these elite breeding lines are also generated during this period. After a careful scrutiny by different research centres, selected breeding lines are evaluated in on-farm trials for obtaining reaction of farmers and extension workers on the yield performance and acceptability. Considering yield records, agronomic data and the reaction to pests and diseases, candidate breeding lines are identified for release as varieties at the annual workshop by the coordinating unit. These are then named and released as new high-yielding varieties to cultivators by the state or central variety release committee.

Indica rice varieties are well known to produce high biomass. They also possess immense variations for panicle weight and grain number per panicle. But the traditional *indica* cultivars are prone to lodging and consequent yield losses. During the post-world war period there was a shortfall in rice availability as Asia faced the problem of increasing population. The importance of breeding for insensitivity to photoperiod was understood in early 1960s in the context of adaptation to a wider range of ecological situations. By the identification and introduction of *DGWG* gene into rice varieties, non-lodging dwarf plant type was achieved. This plant type provided a dramatic improvement in yields harvested by the farmers[3]. With introduction of new seeds of photoperiod-insensitive dwarf rice varieties like IR 8 in 1966 and Jaya in 1967, along with other inputs, fertilizer and water, production increased rapidly. The amount of nitrogen applied per hectare in south and south-east Asia more than doubled in the next five years. A perceptible shift occurred in many countries from a growth dependent upon expansion in land area to a growth based on increased yield per hectare. Initially variability in physical environment was the major reason for the difference in the acceptance rates for new varieties not only between countries, but also within countries. Within a decade, rapid strides were made in the development of stable, and widely adaptable varieties that were insulated against biotic and abiotic stresses. So far, the AICRIP programme has aided actively in the development and release of 632 rice varieties[4]. With such massive efforts, India has reached sustained self-sufficiency in rice. This attracted international attention as it called for sharing and exploitation. The situation was ripe to establish effective linkages for

Table 1. Rice varieties developed in India and released in countries around the world

Country where released	Number	Name/ designation	Cross	Source	Released region	Name given	Year released	Ecosystem
Afghanistan	IET 1415	CR 44-11	TKM 6/IR 8	CRRI	South Asia	–	1975	Irrigated
Afghanistan	IET 355	Cauvery	TKM 6/TN1	DRR	South Asia	–	1975	Upland
Afghanistan	IET 953	Padma	T141/TN1	CRRI	South Asia	–	1975	Irrigated
Benin	–	CO 38	IR 8/CO.25	TNAU	Sub-Saharan Africa	–	–	Irrigated
Benin	–	RAU 4072-13	IR 1833-208-6-3/ Mahsuri	RAU	Sub-Saharan Africa	RAU 407	1991	Upland
Bhutan	–	Barkat	Shinei/China 971	SKUA-S&T	South Asia	Barkat	1992	Irrigated
Brazil	IET 2881	Seshu	IR 24/T141	DRR	Latin America and The Caribbean islands	–	1984	Upland
Burkina Faso	IET 2885	Vikram	IR 8/Siam 29	DRR	Sub-Saharan Africa	–	1979	Irrigated
Burkina Faso	IET 1996	RP 4-2	T90/IR 8	DRR	Sub-Saharan Africa	–	1985	Irrigated
Burkina Faso	IET 1879	Vijaya	T 90/IR 8	CRRI	Sub-Saharan Africa	–	1997	Rainfed lowland
Burundi	–	Savithri	Pankaj/Jagannath	CRRI	Sub-Saharan Africa	–	–	Irrigated
Cambodia	IET 7435	OR 142-99	Pankaj/Sigadis	OUAT	South East Asia	Sante-pheap 3	1992	Rainfed lowland
Cameroon	IET 723	Jaya	TN1/T 141	DRR	Sub-Saharan Africa	–	1977	Irrigated
China P.R.	–	M 114	Mahsuri mutant 3628	KAU	East Asia	8085	1981	Irrigated
Cote d'Ivoire (Ivory Coast)	IET 723	Jaya	TN1/T 141	DRR	Sub-Saharan Africa	–	–	Irrigated
Dominican Republic	–	IR 2153-276-1-10-PR 509	IR 1541-102-6-3/IR 24*4 // *O nivara*	PAU	Latin America and The Caribbean islands	Juma 62	1986	Irrigated
Ghana	IET 2885	Vikram	IR 8 / Siam 29	DRR	Sub Saharan Africa	Afife/ GR 17	1982	Irrigated
Iran	IET 1990	Sona	GEB 24/TN1	DRR	West Asia & North Africa	Amol 3	1982	Irrigated

contd...

Table 1. *(contd...)*

Iraq	IET 8113	RP 2095-5-8-31	Vikram/Andrewsali	DRR	Sub-Saharan Africa	–	–	Rainfed lowland
Kenya	IET 6985	AD 9246	ADT 31/AD 198	TNAU	Sub-Saharan Africa	–	–	Irrigated
Kenya	–	Basmati 217	–	–	Sub-Saharan Africa	–	–	Irrigated
Malawai	IET 4094	Kitish	BU 1/CR 115	CRRI	Sub-Saharan Africa	Senga	1993	Irrigated
Mali	IET 1444	Rasi	TN1/CO 29	DRR	Sub-Saharan Africa	IET 1444	1984	Rainfed lowland
Mali	IET 723	Jaya	TN1/T 141	DRR	Sub-Saharan Africa	–	–	Irrigated
Mali	IET 1879	Vijaya	T 90/IR 8	CRRI	Sub-Saharan Africa	–	1978	Irrigated
Mauritiana	IET 723	Jaya	TN1/T 141	DRR	Sub-Saharan Africa	–	–	Irrigated
Myanmar	–	Mahsuri mutant	–	–	South-east Asia	Ma Naw Thu Kha	1977	Irrigated
Nepal	IET 2935	CR 123-23	Dunghansali/Jayanti	CRRI	South Asia	Durga	1978	Upland
Nepal	IET 1444	Rasi	TN1/CO 29	DRR	South Asia	Bindes-wari	1981	Upland
Nepal	–	K 39-96-1-1-1-2	CH 1039/ IR 580-19-2-3-3	SKUA-S&T	South Asia	Khumal 3	–	Irrigated
Nepal	–	IR 2298-PLPB-3-2-1-1B	CICA 4/KULU	PAU	South Asia	Himali	1982	Irrigated
Nepal	–	IR 3941-4-PLP2B	CR 126-42-5/IR 2061-213	PAU	South Asia	Kanchen	1982	Irrigated
Pakistan	IET 4094	Kitish	BU 1/CR 115	CRRI	South Asia	DR 82	1984	Irrigated
Paraguay	IET 4094	Kitish	BU 1/CR 115	CRRI	Latin America and The Caribbean islands	CEA 1	1989	Irrigated
Paraguay	IET 5612	R 22-2-10-1	IR 22/Sigadis	KKV	Latin America and the Caribbean islands	CEA 3	1989	Irrigated
Senegal	IET 1444	Rasi	TN1/CO 29	DRR	Sub Saharan Africa	–	1981	Upland
Senegal	IET 723	Jaya	TN1/T 141	DRR	Sub-Saharan Africa	Jaya	–	Irrigated
Tanzania	IET 4790	BIET 360	IR 8/CH 45	RAU	Sub-Saharan Africa		1986	Irrigated
Tanzania	IET 1444	Rasi	TN1/CO 29	DRR	Sub-Saharan Africa	–	1984	Upland
Tanzania	IET 2397	RP 143-4	IR 8/HR 19//IR 8	DRR	Sub-Saharan Africa	Katrain 1	1984	Rainfed lowland
Tanzania	IET 360	L 5P23	GEB 24/TN1	CRRI	Sub-Saharan Africa	–	–	Irrigated
Tanzania	IET 1891	Sabarmati BC 5/55	TN1/Bas.370//Bas.370	IARI	Sub-Saharan Africa	Subamati	–	Rainfed lowland
Togo	IET 1444	Rasi	TN1/CO 29	DRR	Sub-Saharan Africa	–	1978	Upland
Venezuela	IET 7288	PR 106	IR 8/Peta 5// Belle Patna	PAU	Latin America and The Caribbean islands	Araure 3	1984	Irrigated
Vietnam	IET 723	Jaya	TN1/T 141	DRR	South-east Asia	–	–	Irrigated
Zambia	IET 7543	RTN 500-5-1	IR 8/RTN 24	KKV	Sub-Saharan Africa	–	–	Irrigated

CRRI, Central Rice Research Institute; DRR, Directorate of Rice Research; IARI, Indian Agricultural Research Institute; KAU, Kerala Agricultural University; KKV, Konkan Krishi Vidyapeeth; OUAT, Orissa University of Agriculture and Technology; PAU, Punjab Agricultural University; RAU, Rajendra Agricultural University; SKUAS&T, Sher-e-Kashmir University of Agricultural Sciences and Technology; and TNAU, Tamil Nadu Agricultural University.

collaboration to international rice improvement programmes around the world.

In 1975, International Rice Research Institute (IRRI), the Philippines started a project similar to the AICRIP model called International Rice Testing Programme (IRTP), with India as a major partner[5]. Later IRTP was renamed as International Network for Genetic Evaluation of Rice (INGER). IRRI's INGER programme has led to the exchange of genetic material among researchers working under diverse rice-growing ecologies around the globe. From INGER nurseries, rice varieties that were bred and released in India, have been directly released for commercial exploitation in many countries. Several elite breeding lines generated in India and identified in AICRIP programme have also been used by many countries as donor parents for traits like pest resistance, yield and quality. Through international collaboration, 33 elite breeding lines developed in India have been released as 46 varieties around the world. These varieties and cultures have been released under different names in a few countries. Global adoption of so many varieties of Indian origin gives a true measure of the strength of Indian rice-breeding programme. Further, this also proves the value of AICRIP model – INGER programme[6–8] as a mechanism for worldwide testing of breeding lines over a wide range of climatic, cultural, soil, pest and disease conditions.

Forty-six Indian varieties have been released by other countries for farmers' cultivation: 25 in Sub-Saharan Africa, 10 in South Asia, 5 in Latin American and the

Caribbean islands, 3 in South east Asia, 2 in West and North Africa and one variety in East Africa. Utilization of India-bred varieties around the world covered all rice ecosystems: 8 varieties in rainfed upland areas, 6 in rainfed lowlands and 32 in irrigated areas (Table 1).

In general, the Indian rice varieties have consistently produced high and stable yields in the international tests. In most environments, Jaya (IET 723) demonstrated its ability for wide adaptability met within the irrigated ecosystem. In fact, Jaya was released in five different countries for commercial exploitation. Likewise, another stable-yielding, widely adopted, photo-insensitive and late-season, water stress-tolerant variety, Rasi, spread across ecosystems in many countries. Rasi (IET 1444) was released for general cultivation in Mali, Nepal, Senegal, Tanzania and Togo. IET 355, IET 2881 and RAU 4072-13 proved their ability to overcome drought stress in fragile rainfed upland ecosystem. Vijaya demonstrated its grain-yielding ability in irrigated ecosystems at Mali, and in rainfed lowlands at Burkina Faso. IET 7435 and IET 2397 recorded high yields at many rainfed shallow lowland test centres across the world. The success of the Indian programme in introducing quality traits from native landraces GEB 24 and Basmati 370 with global acceptance is indicated by the release of Sona, Basmati 217 and Sabarmati. These varieties possess improved quality characteristics such as attractive translucent grains with good texture or aroma. Blast resistance and cold tolerance are the two important traits needed in a variety for its adoption in hill ecosystem. The release of cultivars Durga, Bindeswari, Khumal 3, Himali and Kanchen in Nepal, and Barkat in Bhutan is a testimony to the success achieved in the introduction of such stress-tolerant traits in Indian rice varieties. Due to its ability to produce high yields even at higher ambient temperature at reproductive phase, Kitish was released in Pakistan, Paraguay and Malawai. The Indian varieties that produced stable high yields in the international tests, or those which possessed resistance to stresses or good quality traits found wide acceptance and claimed release in several countries around the world.

The future poses a more challenging task of finding enough rice to feed the ever-increasing population. The targeted global production is 880 million tonnes of unmilled rice by 2020. This increase in rice production must be achieved from less land and with less labour, less water and less pesticides. And it must be sustainable. The demand for rice is expected to grow rapidly over the next two decades, especially in some of the Asian countries: 65% in the Philippines, 56% in Malaysia, 51% in Bangladesh, 46% in India, 45% in Vietnam, 42% in Myanmar and 38% in Indonesia. With a rich and diverse germplasm resource, India must continue to lead in rice improvement programme to sustain self-sufficiency in the future. The AICRIP programme must further be strengthened to aid the exchange and use of rice genetic material generated inside and outside the country. India must also continue to actively support and collaborate with IRRI's programme, so that world population gets sufficient rice to eat.

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