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Non-Basmati Rice Varietal Pipelines
Concept to Product

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Foreword

It gives me immense pleasure to introduce the Bulletin on “Non-Basmati Rice Varietal Pipelines: Concept to Product”. This bulletin aims to present the varietal product pipelines in which active research work is being undertaken mainly in the institute as well as in the country particularly related to non-basmati rice.

ICAR-CRRI has been at the forefront of rice research and development, striving to enhance agricultural productivity, improve sustainability and contribute to food security in India. Over the years, the Institute has developed about 185 high-yielding rice varieties, including six hybrids, for all kinds of ecologies available in the country. Besides, it has made significant strides in developing innovative technologies and solutions to address the challenges faced by farmers and the agricultural industries.

This Bulletin is a testimony to ICAR-CRRI's commitment to promoting demand-led breeding in specific agro-ecological situations and market preferences. It will serve as a valuable resource for scientists, students and the seed industries targeting most useful varieties for stakeholders incorporating various parameters *viz.*, desired market segment, product profile, key agronomic and quality traits, tolerance required for important biotic and abiotic stress factors, agro-ecology (hydrological and topography), states/ regions of the county and area (ha) targeted for necessary innovations in the realm of rice varietal development.

The bulletin provides detailed insights into a diverse range of pipelines required for the development of varietal technologies in different categories *viz.*, rainfed, irrigated, early, medium and late situations prevalent in the country. Besides, the land types, *viz.*, upland, medium and lowland require specific varieties to cater to the need of farmers. Moreover, the climate change poses a challenge requiring varieties with sustainable climate resilience. Furthermore, it focuses on the internal and export markets for specific varietal products to address the need of millers and consumers. It covers various aspects of rice production, such as seed development, crop management, pest and disease control, post-harvest processing, value addition, and many more. Each pipeline is accompanied by a concise yet comprehensive description of its features, and potential stakeholders.

This bulletin will encourage rice scientists, students, industry professionals, and policymakers of the country to explore the comprehensive requirements that can effectively improve research and market interventions. I express my appreciation to the authors and contributors of this bulletin for compiling this document.

Dr. AK Nayak
Director, ICAR-CRRI

Preface

Rice serves as the staple diet for approximately four billion people, half of the global population, providing the primary source of calories and nutrition for billions. In India, rice is more than just a crop- it's a way of life, deeply intertwined with the nation's identity, tradition, culture, and socio-economic fabric. Over 65% of the Indian population depends upon rice as their primary source of nutrition. India is one of the largest producers and exporters of rice. Rice thrives in India's diverse agro-climatic zones, from the waterlogged fields of Kerala to the high-altitude terraces of the Himalayas. This versatility ensures food production across various regions, sustaining India's massive population for which it is considered as economic backbone of farmers. As a major contributor to India's Public Distribution System, it helps ensure food availability to low-income families, playing a crucial role in reducing hunger and malnutrition. The rice sector aligns with India's efforts to achieve Sustainable Development Goals by promoting efficient water use, climate resilience, and inclusive agricultural practices.

This publication classifies rice breeding strategies into different pipelines for product development that are best suited for sustainable rice cultivation. These pipelines are defined based on both biophysical factors and the product profile for rice within the country including ecology, duration, targeted area, core target geography, key defensive traits, key agronomic traits along with suitable grain quality that would be very important for effective planning and development of suitable varieties and other products.

The pipelines have been categorized the rice cultivation areas in India into two major groups, rainfed and irrigated followed by sub-groups in each category. Besides, one 'speciality rice' pipeline has been conceptualised based on the special traits of rice viz., aroma, bio- fortification, low GI, low phytic acid along with emerging industrial, internal market and export needs of the country. It emphasizes maximizing productivity in the pipelines and outlines the ideal requirements to improve the efficiency and profitability of rice varieties. It will encourage demand led breeding and may help to maximize the efficiency of a breeder in relation to the ecological situation and the resultant product/ variety which is supposed to be more acceptable to the stakeholders.

While preparing this bulletin, we received tremendous support from the authors, for which we extend our heartfelt gratitude and sincere appreciation. We also acknowledge the invaluable role played by the Director of ICAR-CRRI, Dr. A.K. Nayak in conceptualizing such pipelines for non-basmati rice. His guidance, encouragement, and thought provoking advice were immensely beneficial throughout the process. The breeders of the entire country have been consulted during the preparation of the manuscript. The suggestion and help from senior breeders and doyen of rice research Dr. B.N. Singh, former Director, ICAR-CRRI, Cuttack, is gracefully acknowledged. Similarly, the cooperation received from Dr. Damodar Raju C., PJTAU, Hyderabad; Dr. S. K. Singh, BHU, Varanasi; Dr. Srinivas Thati, ANGRAU, Guntur; Dr. Deepak Sharma IGKV, Raipur; Dr. S.R. Das, OUAT, Bhubaneswar; Dr. Sanjay Chhetia, AAU, Jorhat; Dr. R.S. Gill and Dr. Jagjeet Singh, PAU, Ludhiana; Dr. Narayan Bhakta and Dr. Santosh Kumar, ICAR-RCER, Patna; Dr. Sanjay Singh, JNKVV, Jabalpur; Dr. Bidhan Roy, UBKV, Coochbehar, WB; Dr. Raghunath Sadhukhan, BCKV, Mohanpur, WB; Dr. Prakash Singh, BAU, Sabour, Bihar; Dr. Praloy Bhowmik, IARI, New Delhi is thankfully acknowledged.

We aspire for this bulletin to become a valuable resource for rice breeders, researchers, graduate students, and educators engaged in rice improvement. Furthermore, it aims to assist policymakers and stakeholders in enhancing efficiency in the product development, achieving greater profitability, and fostering higher sustainability.

Authors

Content

Introduction

Rice is the staple food of about 800 million people in India and an important cereal for food security (Pathak et. al, 2020). It covers 44 million hectares of area with an average production of 120 million tonnes and a productivity of 2.7 tonnes per hectare. (Govt. of India, 2022). Besides meeting domestic demand, India exports about 20 million tonnes of rice annually (Madhu et. al., 2023) earning valuable foreign exchange for the country. The demand for rice to meet the food requirements of the Indian and global population is increasing (Mondal et al. 2022; Samal et al. 2022) while resources such as land and water are decreasing day by day. There is also a shortage of labour during peak periods like transplanting, weeding, and harvesting. Therefore, more rice has to be produced in future years with less land, water, labour, and other inputs in the years to come. Hence, the productivity of rice has to be increased to meet the future demand as the scope of the horizontal expansion in area is very limited.

Since its inception, ICAR-CRRI has made significant contributions to different aspects of rice research. To date, it has released a total of 185 high-yielding rice varieties, including six hybrids, for cultivation in various ecological situations. Some of these CRRI varieties have gained popularity among farmers and have become predominant in certain states, covering an estimated area of about 9.92 million hectares. These varieties (representing approximately 13% of the rice varieties released in the country), contribute about 20% of the rice cultivation area, yielding about 30.01 million tonnes of paddy (23% of national production). The incremental production of rice with CRRI varieties was 1.5 million tonnes, contributing ₹3,064.08 crores to farmers' additional income and Rs 3268 crores of cumulative net profit in 2022-23 (Bisen et al., 2024).

Selecting the appropriate variety is crucial for successful rice cultivation. To ensure higher yields and increased profitability, it is important to choose varieties that are locally adapted to specific climatic conditions, ecosystems, growing seasons, and durations. Additionally, the chosen variety should be resilient to biotic and abiotic stresses and meet changing consumer demands. Furthermore, it must align with the chosen establishment method and management practices to achieve its full yield potential.

The global changes in consumer food preferences necessitate a reorientation of breeding strategies. There is a growing demand for nutrient-dense, high-antioxidant, low-GI, low-phytate, and pharmaceutically acceptable high-value rice to provide better nutrition, health benefits, and higher income.

The traditional pedigree-based varietal development process is slow (8-10 years), resource-intensive, inefficient and has a significantly low selection intensity for achieving higher genetic gain for yield. Additionally, a major challenge lies in the non-replacement of very old rice mega varieties, such as Swarna, MTU1010, MTU1001, Lalat, Pooja, Ranjit, Satabdi, and IR 64, in farmers' fields (Samal et al. 2022), despite the release of many high-yielding varieties (HYVs) and hybrids in recent years. Rice breeders need to strategically address these challenges and reorient the overall breeding strategies, product development to deliver higher genetic gains in a cost-effective manner. The breeding programs need to be strengthened, reoriented, and modernized to effectively address the current challenges of meeting the varietal requirements through a well-deserved product pipeline. These include demand-led breeding, modern population breeding strategy, speed breeding including doubled haploid breeding for faster product development, genomic selection, and precision breeding, as well as a robust seed system for rapid varietal turnover and improved adoption.

Rice Ecosystems in India

Rice is cultivated in different ecosystems in India (Huke and Huke 1997; Singh 2006; Samal *et al*. 2011) which can be broadly classified as Irrigated and Rainfed. All India Coordinated Rice Improvement Project (AICRIP) has been conducting research trials over the past 60 years based on several criteria: land type (irrigated/rainfed), hydrology, cultivation practices, duration, grain type, speciality traits, etc. The area under different systems of cultivation is different. The surface and groundwater irrigated area under rice is expanding progressively due to several irrigation projects/schemes financed by the state and central governments. The private sector also invests in the creation of irrigation facilities.

Out of 44.0 mha, the dry season and *boro* rice area is about 5.0 mha. The rest 39.0 mha is cultivated during the wet season. Out of that about 40 % is rainfed and the rest 60% is irrigated. The irrigated rice during the *kharif* season has been divided into three groups i.e. early, medium, and late depending on the duration of the crop, covering an area of about 21.01 mha. Within the total irrigated area, AICRIP conducts separate trials for aerobic rice that is grown under limited irrigated situations. Therefore, a separate section for aerobic rice has been devoted that acquires an area of approximately 2.0 mha. Rainfed area is again divided into rainfed upland and rainfed lowland. Rainfed lowland is further divided into rainfed shallow lowland, semi-deep and deep-water ecology. The quality rice is an important component of different pipelines which includes aromatic grain type. Moreover, in coastal saline and inland salt affected soils, rice is grown in 3.1 mha and 3.8 mha area, respectively. All three categories have been incorporated in different irrigated and rainfed system of cultivation (Table 1). The coastal saline and inland salt-affected soils are primarily under rainfed agriculture, as these regions often face challenges like salinity and waterlogging. However, specific data on the exact percentage of areas under rainfed agriculture is not readily available. These regions typically rely on monsoon rainfall, especially during the *kharif* for successful rice production.

The irrigated as well as rainfed system of cultivation is further divided into transplanted and direct seeded. The direct-seeded rice is further divided into dry direct-seeded and wet direct-seeded. Similarly, rainfed rice is classified into different categories as per the water table during the life cycle of the crop. The varietal requirements of different systems of cultivation are different and need to be addressed accordingly.

Table1. Estimated area* of rice in different ecologies in India

Sl	Hydrological group	Ecology name	Area (mha)	Subtotal (mha)	Remarks
01	Irrigated	Irrigated Kharif	21.1	26.1	59.3% Irrigated

Sl	Hydrological group	Ecology name	Area (mha)	Subtotal (mha)	Remarks
02		Dry season rice/ Boro	5.0		
03	Rainfed	Rainfed upland	4.8	17.9	40.7% rainfed
04					
05		Rainfed shallow lowland	10.1		
		Semi-deep/Deep	3.0		
06		Quality rice	0.5		Area under Quality, CS, and ISAS have been accommodated in Rainfed and irrigated
07		Coastal saline (CS)	3.1		
08		Inland salt-affected soil (ISAS)	3.8		
		Total		44.0	

*Source: (updated from Pathak et. al. 2020 & Pradhan et.al., 2021)

A. Rainfed Rice: It is characterized by areas that solely rely on rainfall for meeting the water requirement of the crop and encompasses both upland and lowland. The rainfed rice area is about 17.9 million hectares, which is about 40% of the total cultivated rice area. The productivity is very low due to the uncertainty of available water. The physical environment of the rainfed ecosystem is often characterised and grouped into sub-ecosystems according to the surface hydrology of rice paddies. Rice cultivars are developed suiting the needs of each sub-ecosystem. Rainfall is an important determinant of the yield of rainfed rice, but other factors such as topography and soil fertility also affect grain yield and choice of cultivars. The rainfed ecosystem may be broadly classified into two categories: 1. Rainfed Upland and 2. Rainfed Lowland

A1. Rainfed Upland

The Upland rice area in India lies in the eastern zone comprising Assam, Bihar, Jharkhand, Eastern M.P., Orissa, Eastern U.P., West Bengal and North-Eastern hill region. Upland rice is mostly grown as direct seeded. The fields are “unbunded” and “bunded”. This is almost a subsistence crop with minimum input. Productivity is very low and unstable due to drought, weeds, light-textured and less fertile soil, nutritional imbalances, poor cultural practices, diseases, insects, and lack of suitable varieties.

A2. Rainfed Lowland

It is usually grown in levelled, “bunded” fields that retain surface water, but the depth and duration of flooding of the soil varies greatly from year-to-year within a growing season. The water supply is variable, and both drought and flooding may occur in the same season. Rainfed lowland rice system is also classified as favourable, drought-prone, submergence-prone, and drought and submergence-prone. Soil fertility is low and problem soils are common in this ecosystem. Most of the farmers are resource-poor. In this ecology, production is highly variable. Lowland rice may be further classified into three categories depending on the depth of standing water in the field *viz*. shallow lowland (below 40 cm), semi-deep water (40-70 cm), and deep water (70-100 cm). While variations in classification might exist depending on specific sources or regions, the ranges provided here more commonly used in India.

B. Irrigated Rice: This refers to the cultivation method that uses irrigation to provide a reliable water supply for rice crop. It is the most sustainable system and is the most widespread rice ecosystem in the world, accounting for 75% of the global rice production. The total area under irrigated rice in India is about 26.1 mha, which accounts for about 60% of the total area under rice cultivation (Table 1). Irrigated rice is grown in bunded fields; irrigation is the main source of water in the dry season and is used to supplement rainfall in the wet season. The major irrigated rice-cropping systems in India include rice-rice, rice-rice-rice, and rice-wheat. The average yield is 4-5 tonnes per hectare. The major problems encountered in this production system include yield instability, biotic stresses and environmental degradation due to unbalanced nutrient use and inefficient irrigation water management.

Systems of rice cultivation

Across various ecosystems, rice is grown using a range of systems or crop establishment methods as described below

A. Transplanted rice (TPR)

In India, most of the rice is traditionally cultivated in puddled transplanted method. This process follows three steps: i) seedling raising in a nursery bed, ii) puddling in the main field and iii) transplanting the seedlings (20-30 days old) in the main field. For puddling operation, the soil is completely ponded with water before ploughing to achieve the puddled condition. It is well established that to achieve the puddled state, a huge amount of water is required i.e. 300-500 mm which is about 30% of the total water requirement for rice cultivation (~1,400 -2,000 mm). Transplantation minimizes agricultural inputs. Although transplanting utilizes a high total volume of water in irrigation, particularly for puddling, it eliminates the need for early irrigation application during the vegetative stages of the plant. It also controls the weeds by restricting the germination and emergence of weeds under anaerobic conditions allowing the development of crop plant without any competition from weeds.

Due to the rising water demands from other sectors of economy, irrigation water for agricultural purposes is increasingly becoming insufficient. Climate change and other weather aberrations add to the water woes in agriculture. In this situation, water saving alternative to puddling operation needs to be discovered. Other disadvantages of puddling include the destruction of soil physical properties through the destruction of aggregates of soil and capillary pores, and clay dispersion. The transplanting process is water, labour and energy-intensive, which affects the environment and simultaneously incurs costs. Transplanting operations usually employ manual labour, which, in recent times, has become scarce as well as costly. Consequently, this poses a major concern for timely transplanting.

In this context, the development of an alternative technology, such as direct-seeded rice, to sustain the long-term production of rice has become inevitable.

B. Direct seeded rice (DSR)

It is a process of crop establishment of rice wherein seeds are sown directly in the main field avoiding the operations like puddling, transplanting and nursery raising, as in TPR. It cuts down the water required for puddling and transplanting operations. The DSR system is basically classified into two distinct groups viz., dry-direct seeded rice (Dry DSR) and wet-direct seeded rice (Wet-DSR) according to seedbed condition.

a. Dry-DSR: The seeds are sown in dry and mostly aerobic soil with broadcasting, drilling or sowing in rows at a depth of 2-3 cm. It is suitable mainly in rainfed areas *viz.,* rainfed uplands, medium lowlands, lowlands, and deep-water ecologies during the wet season, some in irrigated areas with precise water control.

b. Wet-DSR: It is practised in puddled soil with the sowing of pre-germinated (sprouted) seeds, which may be an aerobic or anaerobic condition. Various sowing methods are followed mostly for favourable rainfed lowlands and irrigated areas with good drainage facilities. It is recommended during the late onset of monsoon which delays timely sowing. It could be further divided into the following types (Adapted from IRRI, Kumar and Ladha, 2011).

   i. *Direct seeding in standing water:* It is useful for puddled soil, where dry or pre-germinated seeds are sown mostly in anaerobic conditions in broadcasting on standing water of 5-10 cm. It is particularly very useful in areas with red rice or weedy rice problems and in irrigated lowland areas with good land levelling.

   ii. *Aerobic wet seeded:* Here broadcasting is done on puddle soil surface. Here row seeding is done in open furrows or on flat soil surface in irrigated areas with good drainage.

   iii. *Anaerobic wet seeded:* It is suitable mostly for anaerobic condition with a thin layer of settling mud. Here row seeding is done in furrows and covered with soil. Here broadcasting and covering are done in irrigated areas with good drainage.

The DSR is being practiced in many medium-deep and deep-water rice ecosystems of the eastern Gangetic plains of India, and on terraced and sloping lands in the northeast and north-western Himalayan region and the western Ghats along the west coast of India. The dry-seeding method is particularly popular in rainfed uplands and lowlands, as well as flood-prone areas, while wet seeding remains a popular method of crop establishment in irrigated ecosystems (Azmi *et al*., 2005; De Dios *et al.*, 2005). The area of DSR in India, Pakistan, and Bangladesh is 14.2 million hectares of the total rice area of 55.3 million hectares (Pandey and Velasco, 2005). Thus, DSR occupies 26% of the total rice area in South Asia. The rainfed DSR can be divided into wet and dry DSR whereas, irrigated DSR (with limited irrigation) is called aerobic rice. When DSR is practiced in the monsoon season and if the soil type is clayey, even the dry seeded rice is likely to be flooded during heavy downpours, and the soil remains saturated throughout the crop growing cycle. Under such a situation, the rice is classified as dry DSR, not aerobic rice. On the contrary, when DSR is cultivated in the dry season on sandy loam soil with only alternate irrigations or in a low rainfall environment, it is called "aerobic rice".

Weed control is a major challenge in dry-DSR, but it can be effectively managed with post-emergent herbicides. This method offers several benefits, up to 30% water savings compared to conventional transplanted rice and a reduction in methane (CH_4) emissions by 18-20%. Besides, dry-DSR reduces labour requirements, enhances seedling emergence, and decreases the risk of lodging. The grain yield is compromised to some extent in wet-DSR. However, when proper management practices are followed, the yield of wet-DSR is comparable to that of transplanted rice. Additionally, wet-DSR increases water productivity by 0.3 to 0.4 kg rice m^{-3} water (Nayak *et al.*, 2020).

ICAR-CRRI breeding program is largely dealing with non-basmati rice. Hence, looking into the domestic and global demand, this bulletin deals with product requirements for non-basmati rice only.

Non-Basmati grains: Market preference and Trends

A. Indian market

India stands as a leading producer of non-basmati rice, cultivating a wide spectrum of varieties that thrive across diverse climatic conditions. The most prevalent among them are Samba Mahsuri, Sona Mahsuri, Ponni, Shatabdi, Banskathi, Pusa 44, HMT, IR-64, Pooja, CR 1014 and Swarna *etc*. These varieties are widely preferred for their distinct characteristics, including grain texture, and cooking quality, besides millers' preference due to high head rice recovery. Additionally, in India, there are several Geographical Indication (GI) tagged varieties, which underscore regional authenticity and quality assurance under which aromatic non-basmati types deserve special mention.

There are major quality preferences of different regions of the country indicating the types of domestic demands.

In the north-eastern part, particularly Assam and Tripura, there is a demand for almost all grain types. Bold grains are mostly preferred in Dhubri and Goalpara (upper Assam) whereas in other places slender grains are preferred. In other north-eastern states, sticky rice (Japonica types) also find its prime place in local food preferences. Besides, short grain aromatic rice also has good demand. In eastern and central states, particularly in Odisha, W.B., Jharkhand, Bihar and eastern-UP, Chhattisgarh and M.P., different grain types have their niche markets. The bold grains (short/ long) are more preferred in rural areas, whereas slender grains are mostly preferred in urban areas. Moreover, short grain aromatic varieties have a demand in all the areas especially during festivities.

In southern states, *viz*., Karnataka, Tamil Nadu, Andhra Pradesh, Telangana there is an overall demand for medium slender grains (Samba Mahsuri type) and short slender grains (Telangana Sona type). However, short bold grains are typically famous for *idly* purpose (CR 1009 type). Besides, short bold (red rice, Jyothi category) are also in demand, particularly in Kerala and Goa.

In central India, especially Madhya Pradesh (MP) and Chhattisgarh, the preferred grain quality of rice varies depending upon the region, cuisine, and local consumption patterns. In Chhattisgarh, rice consumption is an indispensable part of their culture.

Aromatic rice varieties like *Jeera Phool, Chinnor* and *Dubraj* with fragrance and fine texture are preferred for festivals and traditional meals whereas, aromatic long-grain rice varieties like Basmati are popular, particularly in urban areas of MP for special occasions. Medium and short-grain rice possessing soft and non-sticky quality is common for daily consumption. However, parboiled rice is widely consumed in rural areas, as it is easier to digest and nutritionally rich. Besides, long bold rice (like Mahamaya) is preferred for making *Poha* (flattened rice) in this region.

Another market for rice with special attention to health concerns is also emerging. As India is now considered as diabetic capital of the world, demand for low glycemic index (GI) rice is increasing. Even the concept of ultra-low GI is also under testing. Besides, nutri-rice which are rich in nutrients like protein, iron, zinc, antioxidants *etc*. are also drawing public attention.

Besides, rice varieties especially bred for meeting specific industrial use like waxy-rice, rice suitable for making wines, wide range of non-alcoholic beverages, popped and puffed rice *etc*. are also in demand in specific pockets of the country.

B. Global Market

Internationally, Indian non-basmati rice also enjoys robust demand owing to its diverse range of varieties and competitive pricing. It caters to a wide array of culinary preferences worldwide, underscoring its role as a staple food commodity of global trade. The sector's ability to consistently deliver quality produce at economically sustainable prices further reinforces India's position as a key player in the global rice industry.

The world population review data states that China is the largest producer of non-basmati rice in the world, followed by India, among the top 10 producers of non-basmati rice listed in Asia. In 2022, China, and India together account for more than half of the rice produced globally. India retains its position as the leading exporter of non-basmati rice in the world, while the Sub-Saharan African region emerged as the largest importer of rice (Anonymous, 2022). According to the rice exporters association, rice exports from India touched 20 million tons in 2021, which includes 16 million tons of non-basmati rice (Madhu *et. al.*, 2023). Rice qualities *viz*., raw, parboiled, broken and sella rice of numerous varieties are consumed and exported under the non-basmati rice category. In 2022, according to the United States Department of Agriculture (USDA), rice consumption in India was estimated as 109.5 million metric tons (Anonymous, 2025). Export of non-basmati rice has gone up from Rs 13,030 crores in 2019-20 to Rs 30,277 crores in 2020-21. This increase in exports is on account of multiple factors, mainly being India capturing new markets namely, Timor-Leste, Papua New Guinea, Brazil, Chile, and Puerto Rico. Exports were also made to Togo, Senegal, Malaysia, Madagascar, Iraq, Bangladesh, Mozambique, Vietnam and Tanzania Republic (Anonymous, 2021).

Certain varieties of non-basmati rice are recognized for their health benefits, including managing in blood sugar levels (due to their low GI), promoting low cholesterol levels, and being a rich source of dietary fiber. Several non-basmati rice have uniform grain size and do not stick upon cooking, which may also be used in delicacies like *biryani* and fried rice, thus driving the market demand for non-basmati rice. Apart from that, several varieties of short-grain aromatic rice are renowned for their rich natural aroma and flavor, which significantly contributes in driving global market.

In this context, the targeted varietal products in the CRRI research programme, encompassing the majority of non-basmati rice, have been systematically classified under different categories.

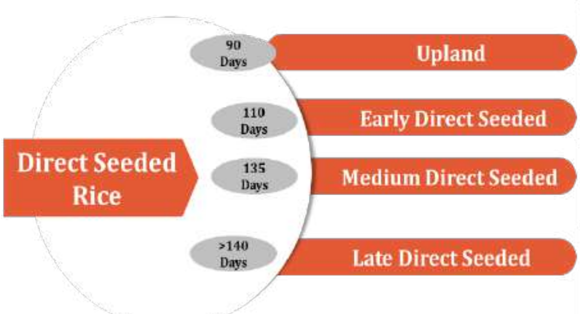
Desired traits of non-Basmati rice: Product Pipelines

The classification of rice varietal pipelines has been strategically organized, with specific emphasis on the environmental adaptability, agronomic sustainability and key product overview parameters *viz*.,

a. Market segment description
b. Product profile description
c. Key agronomic and quality traits including biotic and abiotic stress tolerance
d. Pipeline size
e. Season
f. Agro-ecology (hydrology)
g. States/ regions of the country

This will help researchers to understand the details of the product profile with necessary clarity, and focus on trait-specific breeding for varietal replacement with prospective genetic gain for yield and desired traits, with the ultimate objective of benefitting the targeted stakeholders including farmers, millers and consumers. The products have been classified under the following pipelines. The entire classification has been broadly categorised under i) rainfed and ii) irrigated followed by sub-classifications (Table 2-12).

Rainfed rice cultivation and direct-seeded rice (DSR) cultivation share notable similarities, especially in terms of adaptability, resource efficiency, and sustainability, especially for farmers in water-scarce environments. In this context, the classification of direct-seeded rice has been structured in alignment with the rainfed rice categories.



Value Added Traits	Must Have traits
High N and P use efficiency; Fe and Zn def. tolerance; Nematode resistance	Drought tolerance, Weed competitiveness/ Herbicide Tolerance
High N and P use eff.; Fe and Zn def. tol, Nematode resistance	Drought tolerance, Anaerobic germination, Weed competitiveness/ Herbicide Tolerance
High N and P use eff.; Fe and Zn def. tol, Nematode resistance	Drought tolerance, Anaerobic germination, Weed competitiveness/ Herbicide Tolerance
>14 days submergence tolerance, BLB, BPH, Sheath blight, blast, stem borer tolerance, , resistance to vivipary germination	Intermittent Drought Tolerance

Fig 1. Classification of Direct seeded rice with their traits

A. Rainfed

1. EDSDP (Early Direct Seeded drought- prone)

It is categorized into two parts, *viz.*, un-bunded and bunded. In un-bunded only 90 days duration varieties are cultivated due to limited water storage, whereas in the bunded type, slightly longer duration varieties, such as 110 days varieties, are cultivated due to increased subsurface water storage facilitated by bunding. As it is grown in rainfed situations drought tolerance is an imperative trait for successful cultivation. This ecology available in almost all the states except high altitude hills. Punjab, Haryana, western UP and Telangana. Here the major challenge is weed management which needs to be tackled with suitable herbicide or with herbicide tolerant varieties.

2. RDSM (Rainfed Direct seeded Medium):

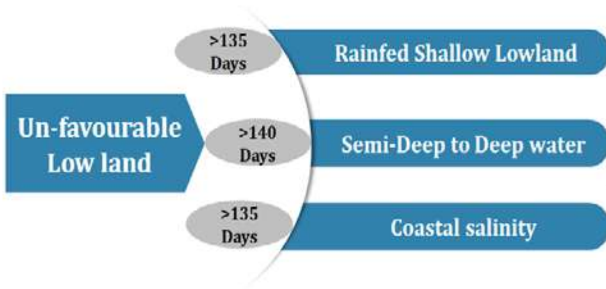
It is typically practiced in Jharkhand, part of Bihar, WB, Odisha, Chhattisgarh, eastern UP, and eastern MP. The duration of the varieties in this category is about 120-135 days. Semi-dwarf high yielding varieties with early growth, drought and flash flood tolerance, high nitrogen use efficiency, and weed competitive ability are essential agronomic traits, although tolerance to anaerobic germination and herbicide are value added traits required here to combat the occasional water stagnation and weed menace. Similarly, the genotypes tolerant to blast, brown spot along with brown plant hopper (BPH) are required for this pipeline.

3. RLSL (Rainfed Late, Shallow lowland):

The rainfed shallow lowland is characterized by water accumulation of 0-40 cm that faces frequent drought and flash floods. As these areas are not suitable for growing most of the other economically important crops, developing high-yielding climate-resilient varieties of rice for these difficult ecologies become very important. While predominantly found in the eastern region (Bihar, Jharkhand, Odisha, Assam, West Bengal, and Tripura), it is also present in other areas, including the southern region (Andhra Pradesh, Telangana, Tamil Nadu, and Kerala), central region (Chhattisgarh), and western region (Maharashtra). It faces major abiotic stresses *viz.*, submergence, stagnant flooding (at least for 20 days), drought, anaerobic condition (during germination) and low light for NE states along with several biotic stresses. High yield along with tolerance to these stresses can improve the livelihood of farmers significantly. This is required in self-pollinated varieties as well as in hybrids. The RDSM and RLSL covers about 10.1mha described as rainfed shallow lowland (Table 1).

4. LSD (Late duration Semi-deep/ deep)

The semi-deep lowland is characterized by water accumulation of 40-70 cm, whereas in deep water 70-100 cm water accumulation is considered, up to one month continuously during the crop growth period. Long duration photo-sensitive varieties are essential for these pipelines. It is available in the eastern region (Assam, Bihar, Madhya Pradesh, Orissa, Uttar Pradesh and West Bengal) covering about 3.0 mha. It faces major challenges of abiotic stress viz., submergence, stagnant flooding, drought (seedling stage), anaerobic germination along with several biotic stresses. The plant should possess moderate to high elongation capacity, a stiff culm, upright leaves, and moderate to high tillering ability. Additionally, it should demonstrate high nitrogen-use efficiency, vigorous early seedling growth, sensitivity to photoperiod, insensitivity to temperature variations, robust kneeing ability, and strong seed dormancy. Because of low tillers, plants should be endowed with heavy panicles for effective yield increment. Besides, there should be resistance to diseases (BB, sheath blight, sheath rot, RTV) and insect pest namely stem borer (SB) and leaf folder (LF) tolerance.



Value Added Traits	Must Have traits
Stagnant Flooding tolerance, BLB, Sheath blight, blast, stem borer tolerance, , resistance to vivipary germination,	Intermittent Drought tolerance, Submergence Tolerance,
>14 days submergence tolerance, BLB, Sheath blight, blast, stem borer tolerance, resistance to vivipary germination, lodging resistance	Stagnant Flooding tolerance, Kneeing ability, intermittent drought tolerance
>14 days submergence tolerance, BLB, Sheath blight, blast, stem borer tolerance, , resistance to vivipary germination	Seedling and reproductive stage Salinity, Stagnant Flooding tolerance,

Fig 2. Classification of Un-favourable lowland rice with their traits

5. CS (Coastal salinity)

It is characterized by salinity, acidity, (soil pH and EC are 2.62 to 5.97 and 0.1 to 9.8 dS/m) excess water and germination stage oxygen deficiency (GSOD). Anaerobic germination (AG) is desirable for late duration genotypes. Salinity tolerance at reproductive stage, along with complete and partial submergence tolerance are also required for successful cultivation in this ecology. High vigour, non-lodging with multiple stress tolerance vis-a-vis productivity benchmark (yield/ha) > 4.0 t/ha would be a boon to the farmers.

6. IS (Inland salinity: alkaline, sodic and sodic saline)

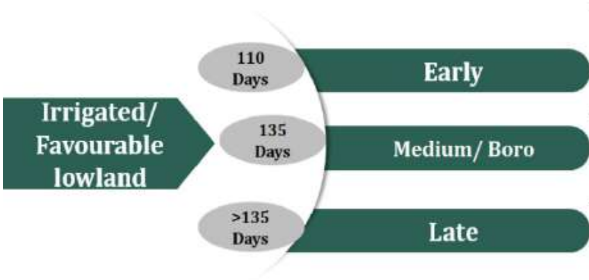
Inland saline soil is classified as saline, sodic and saline-sodic soil. Saline soil is characterized with <13 sodium adsorption ratio (SAR), <15 exchangeable sodium percentage (ESP) of total CEC, <8.5 pH and >4 dSm-1 EC. Salinity stress tolerance, particularly during the seedling and reproductive stages, is the most dominant abiotic challenge in this ecology. On the other hand, sodic soil is characterized by SAR > 13, ESP > 15, pH ranging from 8.5 to 10.0, and an EC of saturation extract < 4 dS m^{-1} (indicating low soluble salts and high exchangeable sodium). Similarly, saline-sodic soil is characterized by SAR > 13, ESP > 15, pH ranging from 8.5 to 10.0, and an EC of saturation extract < 4 dS m^{-1} (where both soluble salts and exchangeable sodium are high). Sodicity stress leads to deficiencies of minerals such as Fe, Mg, P and Zn. Water logging stress is a major issues in these ecology. High vigour, stable grain yield and resilience to multiple stresses, alongside a productivity benchmark exceeding 4.0 t/ha, would greatly benefit farmers.

B. Irrigated

7. IEM (Irrigated Early/ Mid-early)

This pipeline is required in almost every region to cater the need for second crop or irrigation availability. The major driver of this system is very high yield and different grain qualities as per regional requirements. Both self-pollinated varieties as well as hybrids fit into this system. The characteristics viz., lodging resistance and high spikelet fertility should be endowed in the varieties for very high yield besides biotic stress resistance predominantly, BLB and false smut.

Similarly, direct seeded (aerobic) rice is coming in a big way to combat the problem of labour shortage. Weed competitive and herbicide tolerant varieties would offer a great opportunity for saving expenditure and earning more profits.



Value Added Traits	Must Have traits
False smut resistance, Lack of high yielding varieties (>6.0 t/ha), lodging resistance	Non-Shattering, resistance to vivipary germination, **Aerobic:** N and P use efficiency; Fe and Zn deficiency tolerance
Lack of very high yielding >7.0 t/ha, lodging resistance,	Seedling Stage Cold tolerance and reproductive stage heat tolerance for **Boro**
False smut resistance, Bakanae disease tolerance, resistance to vivipary germination,	Lodging resistance

Fig 3. Classification of Irrigated favourable lowland rice with their traits

8. IMTS: (Irrigated Medium Transplanted)

It is one of the major pipelines, extended in eastern, southern and central regions of the country. Long or medium slender grains are preferred followed by long/short bold varieties with good eating quality. The most important agronomic trait includes semi dwarf or a little more height (up to 120 cm), high yield, lodging resistance, high harvest index along with biotic stress resistance. The major diver of this pipeline is very high yielding varieties for breaking yield ceiling (>7.0 t/ha), with improved lodging resistance and tolerance against emerging diseases such as false smut, tungro, and bakanae.

9. ILTS (Irrigated Late Transplanted)

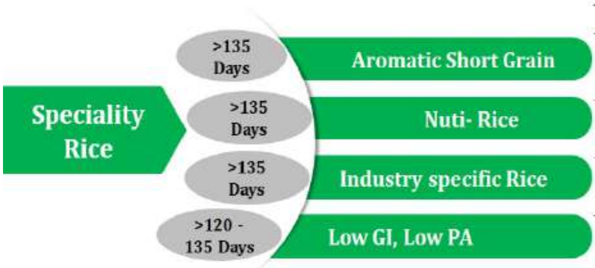
This is one of the extensively covered groups practiced in eastern (Odisha, WB, UP, Bihar, Jharkhand, Assam, Mizoram, Arunachal Pradesh and Tripura), southern (AP, Puducherry) and central (MP, Chhattisgarh, Maharashtra) region of the country. The duration of this group is 135-145 days. This is a major group that covers late-maturity irrigated land and favourable shallow lowland. The plant type, phenotypically, is characterized by late duration, semi-dwarf stature or slightly taller height (up to 120 cm), high yield potential, and resistance to lodging. The preferred grain type is long or medium slender followed by long/short bold. Many mega varieties rule in this pipeline viz., Swarna, Samba Mahshuri, MTU 1075, etc. However, critical gaps remain, including the lack of very high yielding varieties to surpass yield ceiling, lodging resistance along resistance for emerging diseases like false smut and bakanae which needs to be addressed.

10. IMTD (Irrigated Medium Transplanted Dry season)

It covers an area of about 5.0 mha. It includes in irrigated and fertile land with maximum productivity. Early to mid-early duration varieties are grown here. The plant type should be of intermediate height (95-110 cm), possessing lodging resistance with high yield (> 6.0 t/ha) and should be endowed with cold tolerance. The grain type preferred is long/medium slender with high head rice recovery (HRR), intermediate amylose content, soft gel, low chalkiness and high nutritive value. The key gap includes lack of high temperature stress tolerance at the reproductive stage and very high yielding variety for higher benefit.

In addition to the aforementioned pipelines across ecological zones, grain quality traits represent another dimension of pipeline classification. These traits ensure premium pricing and address higher market demand, including export potential, and have been distinctly categorized as 'speciality premium rice.'

11. Speciality premium Rice



Value Added Traits	Must Have traits
High HRR, Lodging resistance	Aroma, soft GC with superior mouth feel and sensory qualities
Lodging resistance and high yield	High Protein, minerals rich, antioxidant rich
High HRR with suitable AC/GC requirements	Industry specific traits
Lodging resistance, High yield	Low GI and Low PA

Fig 4. Classification of speciality premium rice with their traits

Aromatic Grain type: This category of aromatic, non-basmati grains is distinguished by its unique fragrance and exceptional culinary qualities, offering substantial potential in both domestic and international markets. It is grown either in irrigated or rainfed area with adequate drainage facility. Significant cultivation areas include West Bengal, Odisha, Chhattisgarh, Uttar Pradesh, Madhya Pradesh, Maharashtra, and Gujarat. Preferred grain types include:

- Short slender/short bold grains (<4mm): Strong aroma, high head rice recovery (>60%), and excellent cooking quality (e.g., *Gobindabhog*, *Tulaipanji* and *Kalonunia* from West Bengal; *Kalajeera* and *Pimpudibasa* from Odisha; *Joha* from Assam; *Kalanamak* from Uttar Pradesh; *Katarni* from Bihar).

- Medium slender grains (<6mm): Length-to-breadth ratio of 2.5-3.0, strong aroma, high head rice recovery (>60%), and pleasant taste (e.g., *Dubraj* from Chhattisgarh; *Chinoor* from Madhya Pradesh).

- Long slender/bold grains (>6mm): Strong aroma, high head rice recovery (>55%), and delightful taste (e.g., Rajendra Bhagwati from Bihar).

a) Nutri-Dense Rice: This includes high protein rice, mineral rich rice (Fe>16ppm and Zn>28ppm) having all grain types with high HRR (>60%) and good taste, e.g., CR Dhan

310 and CR Dhan 324 (high protein), CR Dhan 315 (high Zinc), high antioxidant viz., *Chakhao*, *Mamihanger* and Jyothi. The key gaps in this pipeline includes, includes susceptibility of available varieties to lodging, bacterial blight, brown plant hopper and blast. Moreover, these are moderate yielders and most of them are landraces, hence requires significant improvement.

b) Industry-specific rice/ Market specific rice: It comprises glutinous rice having amylose content of <5%, medium to long bold grain type (HRR>60%), rice suitable for *Idly, dosa* (Savitri), flattened rice (Mahamaya, Jaya), puffed rice / *mudhi* (var-Lalat), rice wine (var- Koshikari), rice soaked water/ *tanka torani etc.*

c) Other traits including GI/ Phytic acid:

   i. *Low GI Rice:* The Glycemic Index (GI) is a measurement system that ranks foods based on their effect on blood sugar levels. With pure glucose at a GI value of 100, the three glycaemic index classifications are available *viz.*, low (<55), medium (56-69) and high (>70). Studies have shown that rice with low GI may result in weight loss, reduced blood sugar levels, lower risk of developing heart disease and type 2 diabetes. Eating of rice with low GI is supposed to keep diabetes under control. Low GI rice are digested and absorbed relatively slowly, resulting in a much slower and smaller rise in blood sugar levels. In this context, work could be focussed on developing/ identifying varieties with low GI (e.g., Improved Lalat) is the need of the hour. The lacunae in this field is the unavailability of commonly released varieties, unavailability of very high yielders and paucity of high GI donors. However, low GI line has a potential market for commercialization and export.

   ii. *Low Phytic Acid (PA) rice:* PA acts as a robust chelator of metal cations to form phytate and is considered as an anti-nutrient as it reduces the bioavailability of important micronutrients. Although the major nutrient source for more than one-half of the global population, rice is a poor source of essential micronutrients. Hence, biofortification and reduced PA content could be a new strategy for improving micronutrient bioavailability in rice. The target of this area is Grain Phytic Acid (GPA) of <1%, with MS, LS and SS grain type and HRR>55%. The challenges include the productivity enhancement as the low GPA genotypes are low yielders with low seed vigour and growth. Besides, very few natural variations are available to be used as donors. The proposed details of product pipelines are outlined in Tables 2-12.

Trait-specific breeding in rice

Trait-specific breeding in rice focuses on developing varieties with specific desirable traits, such as improved yield, quality, and resistance to pests and diseases, to meet specific agricultural, environmental, or consumer needs. This uses classical breeding approach as well as modern techniques like marker-assisted selection and genome editing to enhance precision and efficiency. By identifying and selecting genes associated with the traits like drought tolerance, pest resistance, improved nutritional quality, or higher yield, breeders can tailor rice varieties to thrive in diverse growing conditions. It addresses food security challenges, consumer preferences, and promotes sustainable agriculture by reducing the need for chemical inputs. Additionally, it involves collaboration among researchers, breeders, and farmers to accelerate the development of superior rice varieties. Overall, trait-specific breeding ensures rice varieties that are resilient, high-yielding, and appealing to consumers. By catering to consumer preferences and preserving genetic diversity, trait-specific breeding ensures long-term adaptability, food security, and economic benefits for farmers and consumers alike.

In this context, the distinct traits have been identified to cater the need of specific pipelines. The traits have been classified as i) Basic trait ii) Essential trait iii) Value added trait and iv) Game changing trait in each pipeline for development of varieties to replace the old varieties successfully. The proposed details of traits in different pipelines have been highlighted in Table 13-16.

Table 2. Product pipeline EDSDP (Early Direct seeded drought prone) with detailed specifications

Sl. No	Product pipeline	Duration (days)	Core target geography and area	Plant height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Varieties to be replaced	Key gaps in the present products
1	**EDSDP** (Early Direct seeded drought-prone)	a. Unbunded < 90 days b. (Bunded ≤ 110 days)	Rainfed Uplands primarily found in Eastern India, However, available in all the States of India except high altitude hills, Punjab, Haryana and Western UP (area about 4.8 mha)	<110 cm (Intermediate)	**Biotic stresses:** Blast, Brown spot (BS), Bacterial blight (BB), Sheath rot, BPH resistance, Nematode resistance **Abiotic stresses:** Drought tolerance, anaerobic germination, flash flood tolerance for bunded upland and low light tolerance for NE States	**Agronomic:** Early growth and vigour, weed competitiveness, High N-Use Efficiency and P Use Efficiency, Tolerance to Fe & Zn deficiency, High Harvest Index (HI) **Special trait:** Herbicide tolerance	All grain types are acceptable. HRR: 55-65%, AC: 20-25%, Low chalkiness.	Vandana, Anjali, Sahbhagi Dhan, CR Dhan 101, CR Dhan 102, Susk Samrat, Indira Barani Dhan-1	1. Drought tolerance at all stages of crop growth 2. Susceptibility to brown spot, BPH, BB. 3. Weed management problem to be addressed effectively 4. Yield >3.0 t/ha

Table 3. Product pipeline RDSM (Rainfed Direct seeded Medium) with detailed specifications

Sl. No.	Product pipeline	Duration (days)	Core target geography and area**	Plant height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Varieties to be replaced	Key gaps in the present products
2	**RDSM** (Rainfed Direct seeded Medium)	120-135	Jharkhand, Part of Bihar, WB, Odisha, Chhattisgarh, Eastern UP, Eastern MP	100-120	**Biotic:** BB, Leaf and Neck blast, Sheath blight, Brown spot Yellow Stem borer (YSB), BPH **Abiotic:** Submergence, drought, Anaerobic germination tolerance.	High yield, Semi-dwarf, Lodging resistance, Early growth and vigour, High NUE, Herbicide tolerance and enhanced weed competitive ability through semi-spreading nature. Tolerant to anaerobic germination	HRR: 55-65% MRR: > 70% AC: 20-25% Medium Slender (MS), Short or long slender(SS, LS) or bold grains (SB/LB)	Swarna Shreya IR 64 Drt 1	1. HYV of irrigated ecology are not suitable for DSR 2. Lack of anaerobic germination, submergence tolerance and drought tolerance 3. Lodging resistance 4. BPH resistance 5. Blast and brown spot resistance

Table 4. Product pipeline RLSL (Rainfed Late, Shallow lowland) with detailed specifications

Sl. No.	Product pipeline	Type	Duration (days)	Core target geography and area**	Plant height (cm)	Key defensive traits	Key agronomic traits	Variety to be replaced	Grain quality	Key gaps in the present products
3	**RLSL** (Rainfed Late, Shallow low land)	a) Self-pollinated	140-150	**Eastern:** Bihar, Odisha, Assam, West Bengal, Tripura, Jharkhand, Chhattisgarh **Southern:** AP, Telangana, TN, Kerala, Puducherry **Western:** Maharashtra and Gujarat	110-140	**Biotic:** **Eastern:** BB, Leaf and Neck blast, Sheath blight, False smut (FS), Sh. Rot, BS, Stem borer, BPH and Gall midge (GM) tolerant **Southern:** BB, Sh. Blight, FS, Blast, YSB, BPH, LF and GM **Central:** BB, Sh. blight, Grain discoloration, FS, BPH, SB, LF and GM **Abiotic:** Submergence, stagnant flooding (at least for 20 days), drought, Anaerobic germination tolerance and low light for north eastern (NE) states	High yield, Late duration, semi tall, Lodging resistance, Early growth and vigour, High NUE and High HI	Swarna Sub-1, CR Dhan 801 (Eastern, Southern, Central); Ranjit/ Ranjit Sub1, Bahadur Sub-1, Gayatri (Eastern); Sarla, Pooja, Pradhan dhan (Odisha); Mahsuri, CR Dhan 802 (Central, Eastern) & Savitri/ Savitri Sub-1 (Eastern, Southern), CR Dhan 800 (Odisha)	Any type of grains, HRR: 55-65% AC: 20-25%	1. Lack of submergence tolerance 2. Very high-yielding varieties and lodging resistance 3. Lines with multiple stress tolerance. 4. For biotic stress only one gene combination not desirable for mega varieties. 5. Submergence tolerance altered husk colour and reduced acceptance of the product. 6. Highly susceptible to BPH, the major emerging pest. 7. HYV not recognised for direct seeding (Needs manipulation through Sub-1 + Con. Breeding for SNORKEL (Evaluation at 50 cm wat. depth
		b) Hybrid					Hybrid: >10% yield over hybrid, >20 % yield over Self-pollinated, > 85% spikelet fertility, Lodging and cold tolerant, High HI CMS: 50% outcrossing in CMS, Yield >3.0 t/ha	PA 6444, Cr Dhan 701, CR Dhan 702	Hybrid: LS, LB, MB, MS grains, HRR: 55-65% AC: 20-25% CMS: MS, SS, LS grains with >50% outcrossing	1. Lack of stress-tolerant varieties, producibility, lodging and false smut

**The Rainfed Late, Shallow low land along with Rainfed Direct seeded medium(pipelines 3&2) covers about 10.1mha with majority of RLSL

Table 5. Product pipeline LDSDD (Late duration Semi-deep/ deep) with detailed specifications

Sl. No.	Product pipeline	Type	Dura-tion (days)	Core target geography and area	Plant height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Variety to be replaced	Key gaps in the present products
4	**LDSDD** (Late duration Semi-deep/ Deep)	Gr. I. Semi-deep	145-160	Assam, Bihar, Madhya Pradesh, Odisha, Uttar Pradesh and West Bengal (about 3.0 mha for both semi-deep and deep)	120-160 cm	**Tolerance to :** **Abiotic:** • Drought tolerance at seedling stage • Submergence tolerance • Moderate Stagnant Flooding tolerance • Capacity of Anaerobic germination • Photoperiod-sensitive & thermo-insensitive **Biotic:** BB, BPH, Sheath blight, False smut, YSB, Leaf folder and Gall midge	• Stiff culm, erect leaves & moderate tillering ability • High N-use efficiency at low N level • Early seedling vigour • Moderate elongation ability • Kneeing ability	All types of grains, HRR: 55-65% AC: 20-25%	Varshadhan (Odisha, WB); Uphar, CR Dhan 510, CR Dhan 505, CR Dhan 506 (Odisha); Sabita (WB); Pani Kekoa, Tar Kekoa (Assam); Jalpriya, NDGR-201 (UP)	Productivity, Lack of very high yielding varieties with good kneeing ability; Lack of lodging, drought and biotic stress tolerance
		Gr. II. Deep	145-160		≥ 160 cm	**Abiotic:** • Prolong Stagnant flooding tolerance with fast internode elongation ability • Drought tolerance at seedling stage • Capacity of anaerobic germination • Photoperiod-sensitive & thermo-insensitive **Biotic:** BB, Sheath blight, False smut, YSB and Leaf folder tolerant	• Stiff culm and erect leaves • Kneeing ability • Good elongation ability • High N- use efficiency at low N level • Early seedling vigour • Aquatic adventitious root • High AGS (arenchymal gas space in root)	HRR: 55-65% AC: 20-25%	Jalmagna, Jalnidhi, Jalbhabani, CR Dhan 500, CR Dhan 508 (Eastern), Amona Bao, Dhepa Bao & Jul Bao, Ranga Bao etc. (Assam)	Productivity, Lack of very high yielding varieties; Lack of lodging, drought and biotic stress tolerance with good kneeing ability

Table 6. Product pipeline CS (Coastal Saline) with detailed specifications

Sl. No.	Product pipeline	Type	Duration (days)	Core target geography and area (mha)	Plant height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Variety to be replaced	Key gaps in the present products
5	CS (Coastal Saline)	Gr. I.	>140 days	Odisha, West Bengal (~1 mha)	>120 cm	**Abiotic:** Tolerance to Salinity, stagnant flooding, submergence, drought and Anaerobic Germination (AG) (in case of direct seeded) **Biotic:** tolerance to BB, Sheath blight, blast, yellow stem borer	High vigour, non-lodging, Productivity benchmark (yield/ha) > 4.0 t/ha	HRR: 55%, AC: 20-25%, LB, LS, MB, MS	Bhutnath, Rahaspanjar, CR Dhan 414, Luna Suvarna, Luna Barial, CR Dhan 412	Lack of multiple stress-tolerant materials, higher productivity, lodging resistance
		Gr. II.	125-140 days	Andhra Pradesh (~0.3 mha)	>100 cm	**Abiotic:** Tolerance to Salinity, Submergence, stagnant flooding	High vigour, non-lodging Producibility benchmark (yield/ha) > 5.0 t/ha	HRR: >55%, AC: 20-25%, LS, MS	RCM 101, RCM 103	Lack of multiple stress-tolerant materials, higher productivity, lodging resistance
		Gr. III.	110-115 (kh) 135-140 (rabi)	Puducherry, Tamil Nadu, A&N (~0.4 mha)	>110 cm	***Kuruvai*** (*Kharif*: June-July) rice: saline sodic (1.15 and 4.50 dS/m for E.C 7.50 and 8.90 for pH) tolerance ***Rabi*** (Oct-Jan): submergence, stagnant flooding, AG in case of direct seeded	***Karuvai*** (*Kharif*): 115 days duration, early vigour, medium tall, ***Rabi:*** 135 days duration, medium tall Producibility benchmark (yield/ha) > 5.0 t/ha	HRR: >55, AC: 20-25% MS white rice	Jarava, CARI Dhan 5, TRY 3, KKL-3	Lack of multiple stress-tolerant materials, lodging resistance
		Gr. IV.	125-140 days	Kerala (~0.25 mha)	>115 cm	Salinity, acidity, (soil pH and EC is 2.62 to 5.97 and 0.1 to 9.8 dS/m) excess water, GSOD tolerance	High vigour, non- lodging Productivity benchmark (yield/ha) > 4.0 t/ha	HRR: >55, AC: 20-25%, MS, MB	VLT5, VLT 8, Vytilla-9	Lack of multiple stress-tolerant materials, higher productivity, lodging resistance
		Gr. V.	125-140 days	Karnataka, Goa, Maha rashtra, Gujarat (~1.2 1 mha)	>110 cm	Salinity tolerance at reproductive stage, complete and partial submergence with brackish water, osmotic stress	High vigour, non- lodging Productivity benchmark (yield/ha) > 4.0 t/ha	HRR: >55%, AC: 20-25%, MS, MB, LS grain	Goa dhan 4, Goa dhan 2, Goa dhan 4, Karjat-7, Panvel-3	Lack of multiple stress-tolerant materials, higher productivity, lodging resistance

Table 7. Product pipeline of IS (Inland Saline ecology : alkaline, sodic and sodic saline) with detailed specifications

Sl. No.	Product pipeline	Duration (days)	Types	Core target geography and est. area (mha)	Plant height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Variety to be replaced	Key gaps in the present products
06.	IS (Inland Saline)	125-140 days	Gr. I. Inland Saline: SAR <13; ESP <15% of total CEC; pH <8.5; EC of saturation extract >4 dS m−1	Gujarat, Rajasthan, Maharashtra, Bihar, Haryana, UP (~1.5 Mha)	<115 cm	Salinity tolerance at seedling and reproductive stages	High vigour, non- lodging, Productivity benchmark: yield/ha >4.0t/ha	HRR:>55, AC: 20-25%, MS, LS grains	CSR 27, CSR 36, CSR 101	Lack of tolerance to salinity at reproductive stage
			Gr. II. Sodic soil: SAR >13; ESP >15%; pH = 8.5–10.0; EC of saturation extract < 4 dS m−1 (low soluble salt content) Gr. III. Saline-Sodic soil: SAR >13; ESP >15%; pH = 8.5–10.0; EC of saturation extract > 4 dS m−1 (high soluble salt content)	UP, Gujarat, Haryana, Tamil Nadu, Karnataka, MP, Punjab, Bihar, AP, Haryana (~3.78 Mha)	<115 cm	Tolerance to sodicity, tolerance to deficiencies of nutritional minerals such as Fe, Mg, P and Zn, water logging tolerance	High vigour, non-lodging Productivity benchmark: yield/ha >4.0t/ha	HRR:>55%, AC: 20-25%, MS, MB, LS grains	CSR 36, CSR 43	Lack of tolerance to multiple abiotic (salinity, sodicity, waterlogging) and biotic stress

Table 8. Product pipeline IEME (Irrigated Early/ Mid-Early) with specifications

Sl. No.	Product pipeline	Type	Duration (days)	Core target geography and area#	Height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Varieties to be replaced	Key gaps in the present products
7	**IEME** (irrigated Early/ Mid-early)	Gr. I. a. Self pollinated	110-125 (Kharif)	**Northern** (Punjab, Haryana, West UP)	100-110	**Biotic stress Tolerance:** **Northern:** Sh. blight, Bakanae, FS, Blast, SRBSDV virus, BB, BPH, YSB, leaf folder	Early duration, High yield, Lodging resistance, spikelet fertility (> 85%), Low light Tolerance in Eastern Region	Long slender with good elongation (preferred), intermediate amylose, Less Chalky, Soft cooked grains (High HRR: 55-65%; MRR> 70%; AC: 20-25%)	PR 126, PR-131 or PR-130 Pusa 44 type with shorter duration (Northern)	Lack of very high-yielding varieties leading to high production; lodging, false smut resistance
				Southern, Eastern and Central (AP, Karnataka, Uttar Pradesh, Bihar, WB, JH, Assam, Tripura, Odisha, Chhattisgarh, MP, Maharashtra)		**Eastern:** BB, Blast (leaf and neck), Sh. blight), BS **Central:** BB, FS, Grain discoloration **Southern:** Blast (leaf and neck), BB, Brown spot, BPH, YSB, G Midge (typically for Tel. Sona), and leaf folder		Eastern & Central: Long slender and long bold in India for consumption and export purpose	MTU 1010, MTU -1156, Ratna & IR 64 (Eastern Central and Southern, including parts of western), Naveen, Lalat (Eastern & Central), Shatabdi, Khitish (WB) for consumption and export	Lack of very high yielding varieties ; varieties tolerant to lodging, false smut & Low light
									Mahamaya (Flattened rice)	
								Southern: Short and medium slender for consumption and long slender for export (test weight: 12-15g)	South India: Telangana Sona (RNR 15048) having short slender grains	
								Kerala and Goa: Pigmented and bold grains for consumption	Jyothi in Kerala	
		b. Hybrid			110-120		High heterosis (>10% over hybrid & >20% over self-pollinated variety), > 85% spikelet fertility, non-lodging, High-test weight (> 22-24) CMS: >50% outcrossing, > 3.0 t/ha, staggering < 10 days	LS, LB, SB, MS grain type, HRR: 55-65% MRR: > 70%, AC: 20-25% CMS: MS, LS grains	US 314, 27P63	Lack of stress- tolerant varieties; producibility, lodging, false smut and low light tolerance (Assam and Tripura)

Sl. No.	Product pipeline	Types	Duration (days)	Core target geography and area	Plant height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Varieties to be replaced	Key gaps in the present products
		Gr. II. Direct seeded/ Aerobic	110-120 (Kharif)	**Northern:** Punjab, Haryana, West UP	100-115	**Stress Tolerance:** **Biotic:** Bakanae, false smut, Blast, BB, BPH, stem borer, leaf folder and Nematode **Abiotic:** Moderate drought tolerance	High yield, Lodging resistance, High seedling vigour, spikelet fertility (> 85%, N and P use efficiency; Fe and Zn deficiency tolerance; weed competitiveness	Any grain type and standard quality traits with shattering tolerance HRR: 55-65% MRR: > 70% AC: 20-25%	PR 126, PR 111 (Northern)	**Scarcity of** a. high yielding varieties (> 5.0 t/ha), b. lodging resistance c. False smut resistance, d. Nematode resistance, e. N use efficiency f. Weed competitiveness
				Eastern and southern: Eastern UP, Odisha, South WB, Assam, Chhattisgarh, Karnatak, TN, AP, Telengana (Aerobic rice covers ~2.0 mha in the entire country)		**Biotic:** Blast (leaf and neck), Sheath blight, Brown spot, BLB, BPH, stem borer, leaf folder, Gall midge and Nematode **Abiotic:** Low light Tolerance in Eastern Region			CR Dhan 201, CR Dhan 202, CR Dhan 203, CR Dhan 205, CR Dhan 206 (Eastern); ARB 6, MAS 26 AND MAS 946-1 (South)	

Table 9. Product pipeline IMTS (Irrigated Medium Transplanted) with detailed specifications

Sl. No.	Product pipeline	Type	Duration (days)	Core target geography and area*	Pl ht (cm)	Key defensive traits	Key agronomic traits	Grain quality	Varieties to be replaced	Key gaps in the present products
08	**IMTS:** (Irrigated Medium Transplanted)	Gr. I. Self pollinated	125 – 135	**Eastern** (Odisha, WB, UP, Bihar, Jharkhand, Assam **Southern** (AP, Karnatak) **Central** (MP, Maharashtra, Chattisgarh) etc **Northern** (Uttaranchal)	100-120	**Stress Tolerance** **Biotic:** **Eastern:** BB, leaf and Neck blast, FS, Sheath rot, BS Tungro, BPH, stem borer, Leaf folder, gall midge **Southern:** Leaf and neck blast, BB, FS, Sh. Blight **Central:** Neck blast, false smut, BB, Sh. Blight, BPH, stem borer, leaf folder and gall midge **Northern:** Sh. Blight, Bakanae, Blast, FS, BB, YSB, BPH, Leaf folder Abiotic stresses: Flash flood (few areas) and low light for NER states	>10% yield over popular Variety, semi dwarf or little more height (up to 120cm) High yield, lodging resistance, High harvest index	**Eastern, Northern and Central:** Long or medium slender (preferred) followed by long/short bold with good eating quality HRR: 55-65% AC: 20-25%, Low chalk for most of the places the country **Southern:** MS or SS grains	MTU 1001 (Eastern, Southern, central and western), CR Dhan 300 (Odisha, WB), CR Dhan 307 (Odisha, WB, Assam), Sarjoo 52, Rajendra Sweta (UP, Bihar) NDR 359 (Eastern, Northern, Central)	a. Lack of very high yielding varieties for breaking yield ceiling (8-10t/ha) b. Most of the varieties are prone to lodging c. Threat of emerging diseases like false smut, Tungro and Bakanae, d. Unavailability of flood tolerant Variety
		Gr. II. Hybrid	125 – 135		110-120		>10% yield over hybrids & >20% over Self poliinated, > 85% spikelet fertility, nonlodging, high HI CMS: >50% outcrossing in CMS, Yield > 3.0 t/ha	LS, LB, MB, MS grains, HRR: 55-65% AC: 20-25% CMS: MS, SS, LS grains with high outcrossing (>50%)	BS6444G, 27P63, Rajalaxmi	a. Most of the varieties are prone to lodging b. Threat of emerging diseases like false smut, Tungro and Bakanae, c. Lack of stress-tolerant materials d. Issue of producibility of very high yield

Table 10. Product pipeline ILTS (Irrigated Late Transplanted) with specifications

Sl. No.	Product pipeline	Type	Duration (days)	Core target geography with area#	Pl ht (cm)	Key defensive traits	Key agronomic traits	Grain quality	Varieties to be replaced	Key gaps in the present products
09	**ILTS:** Irrigated Late Transplanted	Gr. I. (Self-pollinated)	135 – 145	Eastern (Odisha, WB, UP, Bihar, Jharkhand, Assam, Mizoram, Arunachal Pradesh, Tripura Southern (AP, PC) Central (MP, Chattisgarh, Maharashtra)	100-120	**Stress tolerance** **Biotic:** **Eastern:** Neck blast, F. smut, BB, Sh. Rot, Br. Spot, BPH, Yellow stem borer, Leaf folder, GM **South:** BB, Sh. Blight, F. smut, BPH, Yellow stem borer, leaf folder and gall midge **Central:** Neck blast, false smut, BB, Sh. Blight, BPH, Yellow stem borer, leaf folder and gall midge **Northern:** Blast, False smut, BB, Bakanae, Sh. Blight, BPH and YSB, LF **Abiotic stresses:** Flash flood (few areas) and low light for NER states	SP: Late duration, semi-dwarf or little more height (up to 120cm) High yield, lodging resistance	Long or medium slender (preferred) followed by long/short bold HRR: 55-65%, AC: 20-25%, Low chalk.	Swarna, Samba Mahsuri, MTU 1075 and MTU 1121 (Eastern, Southern, central and western), Pratikshya (Odisha, WB), Rajendra Mahsuri (Bihar)	a. Lack of very high yielding varieties for breaking yield ceiling b. Most of the varieties are prone to lodging c. Threat of emerging diseases like false smut, Tungro and Bakanae,
		Gr. II. (Hybrid)	135 – 145				>10% yield over hybrids & >20% over Self poliinated, > 85% spikelet fertility, non-lodging, high HI CMS: >50% outcrossing in CMS, > 3.0 t/ha, Photoinsensitive	LS, LB, MS grain, HRR: 55-65% AC: 20-25% CMS: MS, SS, LS with high outcrossing (>50%)	CR Dhan 701, Arize Dhani, PA 6444	

#The estimated total area under irrigated early, medium and late (Pipelines 7,8&9) covers about 21.1mha

Table 11. Product pipeline IMTD (Irrigated Medium Transplanted Dry season) with specifications

Sl. No.	Product pipeline	Types	Duration (days)	Core target geography and area (mha)	Plant height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Varieties to be replaced	Key gaps in the present products
10	**IMTD** (Irrigated Medium Transplanted Dry season)	Gr. I. Dry season rice	Medium maturity 110-125 days	East M.P., Odisha, East UP, A.P, Telangana	100-110	**Stress tolerance:** **Biotic:** Blast (leaf and neck), Brown spot, False smut, BPH, Stem borer **Abiotic:** Seedling stage cold and heat tolerance at reproductive stage.	Intermediate plant height (95-110 cm) Lodging resistance High yield (> 6.0 t/ha)	Long/medium slender grain type High head rice recovery (HRR) Intermediate amylose content Soft cooked grains Low chalkiness High nutritive value (preferred)	IR 64, Lalat, Gautam, MTU 1010, CR Dhan 601 Telangana Sona, KNM 1638	Lack of high temp. stress tolerance at reproductive stage
		Gr. II. Boro rice	155-170 days	Assam, W.B., Bihar (Total IMTD area including *boro* covers 5.0 mha)		**Biotic:** Blast (leaf and neck), sheath blight, sheath rot, brown spot, Stem borer **Abiotic:** Seedling stage cold and heat tolerance at reproductive stage			Gautam, Satyam, Santosh, Luit, Arize 6444, Shatabdi, Lalat, Cr Dhan 602, Gautam, MTU 1010, Gontra Bidhan 3, IR 64	Lack of Vey High yielding varieties

Table 12. Product pipeline Speciality Premium Rice with specifications

Sl. No.	Product pipeline	Types	Duration (days)	Core target geography and area (mha)	Plant height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Varieties to be replaced	Key gaps in the present products
11	**Specialty Rice**	Gr. I. Aromatic Grain type	120-145	Irrigated or rainfed areas with proper drainage systems in W.B., Odisha, Chhattisgarh, U.P., M.P., Maharashtra, Gujrat (> 0.5 mha in the entire country)	100-120 cm (target)	**Stress tolerance:** **Biotic:** BB, Blast BPH and stem borer **Abiotic:** Submergence and Drought tolerance	Lodging resistance, High grain fertility, higher tiller no./plant, Semi-dwarf, high grain number, High HI	Short slender/ short bold grain <4mm, Strong aroma. High HRR (>60%). Soft cooked rice, Good taste	*Gobindabhog, Tulaipanji, Kalonunia* (WB) *Kalajeera, Dhusara, Pimpudibasa Geetanjali* (Odisha), *Joha* (Assam), *Kalanamak, Badshabhog, Adamchini* (UP), *Katarni, Sonachur Rajendra Kasturi* (Bihar), *Chattri* (M.P), *Ambe Mohar* (Maharastra), *Jeeraphool, Ramjeera* (Chhattisgarh)	Susceptible to lodging, stem borer, BPH, BB, and blast. Low yielders as most of popular varieties are landraces.
								Medium slender grain <6mm, L/B ratio: 2.5-3.0, Strong aroma. High HRR (>60%). Soft cooked rice Good taste	*Nagri Dubraj* (Chhattisgarh), *Chinnor, Kalimooch* (MP)	
								Long slender/ bold grain > 6mm, Strong aroma. High HRR (>60%). Soft cooked rice Good taste	Rajendra Bhagwati (Bihar)	
		Gr. II. Nutri-Rice	120-145 days (Targeting popular varieties)	Irrigated or rainfed areas with proper drainage system in W.B., Odisha, Chhattisgarh, U.P., M.P., Maharashtra, Gujarat	100-125cm (target)	**Biotic:** BB, Blast, sheath blight BPH and stem borer **Abiotic:** Submergence and Drought tolerance	Lodging resistance, High grain fertility, higher tiller no./plant,	High protein rice: Mineral rich rice: Fe>16ppm Zn>20ppm All grain types High HRR (>60%). Good taste	High protein: CR Dhan 310, CR Dhan 324, CR Dhan 411 High zinc: CR Dhan 311, CR Dhan 315, DRR Dhan 45	Absence of multi-nutrient-rich rice varieties
								Antioxidant rich rice	*Chakhao, Mamihanger*, Jyothi	-

Sl. No.	Product pipeline	Types	Duration (days)	Core target geography and area (mha)	Plant height (cm)	Key defensive traits	Key agronomic traits	Grain quality	Varieties to be replaced	Key gaps in the present products
		Gr. III. Industry specific rice/ market specific rice	120-130 days	NEHR/ industry specific product for local market and export	100-125cm (target)	High-yielding, Biotic stress-tolerant (field resistance)	Lodging resistance, High grain fertility, higher tiller no./plant, grain fertility Low light tolerant and cold tolerance	Glutinous rice Amylose content <5%, Medium to Long bold grain type. HRR>60% *Idly, dosa* (savitri), flattened rice (Mahamaya, jaya), Puffed rice (*Mudhi*, var-Lalat), Rice wine (Koshikari), *Tanka torani*	*Aghanibora, Ghew Bora*	Susceptible to Lodging, leaf and neck blast. Low yielders
		Gr. IV. a. Low GI	All maturity duration	W.B., Odisha, Chhattisgarh, U.P., M.P., Maharashtra, Gujrat, Haryana, Punjab	100 cm -120 cm	High-yielding, Biotic stress-tolerant (good field resistance)	Lodging resistance, High grain fertility, higher tiller no./plant, grain fertility	Low GI < 55 MS, LS and SS grain type HRR>55	Improved Lalat and Telangana Sona having low GI. The dominant variety of the location may be replaced.	a. Low yielder, very few availabilities of donor. b. Low GI line has a potential market for commercialization and is suitable for diabetic patients.
		Gr. IV. b. Low Grain Phytic acid						Grain Phytic acid (GPA): <1% MS, LS and SS grain type HRR>55	Khira is a reference variety for low GPA. The dominant variety of the location may be replaced with variety having more yield potentiality	a. Low GPA are low yielders, low seed vigour and growth. b. Very few natural variations are available for donor. c. Minerals bio-availability is low due to high GPA.

Table 13. Trait specificity of pipelines: Rainfed-Normal

Product pipeline	Type	Basic Trait	Essential traits	Value added trait	Game changing trait
1. Rainfed EDS (Early Direct seeded drought-prone)	Gr. I. Unbunded Gr. II. Bunded	Self-pollinated: Intermediate amylose (AC: 20-25%), Less Chalky, Soft grain High HRR: 55-65%; MRR> 70% Hybrid: CMS: MS, LS grains	Drought tolerance, early vigour	Stable yield of 5.0 t/ha, LS or MS grain, aroma, nematode resistance, High N and P use efficiency; Fe and Zn deficiency tolerance	Weed competitiveness/ herbicide tolerance
2. RDM (Rainfed Direct seeded Medium)			Drought tolerance, early vigour	Anaerobic germination, Stable yield of 6.0 t/ha, LS or MS grain, aroma; nematode resistance, High NUE and PUE; Fe and Zn deficiency tolerance	weed competitiveness/ herbicide Tolerance
3. RLSL (Rainfed Late, Shallow lowland)	Gr. I. Self-pollinated Gr. II. Hybrid		Drought tolerance at early stage, early vigour, tolerance to viviparous germination	Anaerobic germination, LS or MS grain type, High HRR, lodging tolerance	Submergence tolerance for 3 weeks
4. Late duration (Semi deep/ deep)	Gr. I : Semi-deep Gr. II: Deep		Kneeing ability Intermittent drought tolerance, stagnant flooding tolerance, good elongation ability	Lodging resistance, Submergence tolerance	High-yielding variety with 6t/ha stable yield

Table 14. Trait specificity of Pipelines: Rainfed-salt affected (Coastal Saline and Inland Saline)

Product pipeline	Type	Basic trait	Essential traits (common for all irrigated pipelines)	Value added trait	Game changing trait
Coastal Saline ecology	Gr. I. Odisha, West Bengal	Tolerance to Salinity, stagnant flooding, submergence, BB, Sheath blight, blast, Stem borer, Drought and Aanerobic Germination (AG)	Salinity tolerance	Long bold grain, high HRR, high micronutrients	Multiple/ combined stress tolerance (Salinity+ submergence/ Stagnant flooding) Salinity tolerance at reproductive stage, lodging resistance
	Gr. II . Andhra Pradesh	Salinity, Submergence, stagnant flooding, lodging resistance	Salinity tolerance	MS/ SS grain, high HRR, high micronutrients	Multiple stress-tolerance (Salinity + submergence), lodging resistance, higher productivity
	Gr. III. Puducherry, Tamil Nadu, A&N	Salinity-sodicity tolerance, submergence, stagnant flooding tolerance, AG	Salinity/ sodicity tolerance	MS grain, high HRR, high micronutrients	Multiple stress-tolerance (Salinity / sodicity+ submergence), higher productivity
	Gr. IV. Kerala	Salinity, acidity, excess water tolerance, GSOD	Salinity tolerance	MB/MS grain, high HRR, high micronutrients	Multiple stress-tolerance (salinity/acidity + waterlogging, lodging resistance
	Gr. V. Karnataka, Goa, Maharashtra, Gujarat	Salinity tolerance at reproductive stage, tolerance to complete and partial submergence with brackish water, osmotic stress tolerance	Salinity tolerance	HRR: >55%, AC: 20-25%, MS, MB, LS grain, high micronutrients	Multiple stress-tolerance (salinity + submergence), lodging resistance
Inland Saline ecology (alkaline, sodic and sodic saline)	Gr. I. Inland Saline	a. Tolerance to salinity levels up to 10-11 dS/m, high pH and poor drainage, waterlogging and harsh soil situations. b. Saline tolerance at seedling and reproductive stage	a. Higher vigour, non-lodging and stable yield even under saline stress (e.g., 4-6 tons/ha). b. Tolerance to BB and blast c. Early to medium (110-135 days) maturity	a. Suitable for both normal and saline-affected soils b. Improved grain quality with higher protein and micronutrient content (Fe, Mg, P and Zn).	a. Tolerance through innovative breeding approach for enhanced salt (Inland Saline), higher sodicity (Sodic soil) and higher salinity and sodicity both (saline-sodic soil) b. Acts as a biological amendment, improving soil health over time
	Gr. II. Sodic soil	a. Tolerance to high sodicity (pH up to 10.0), capacity to thrive in soil with high alkalinity, harsh soil condition and waterlogging b. Tolerance to high sodicity at seedling and reproductive stage		a. Ability to perform well in sodic and normal condition b. Improved grain quality with higher protein and micronutrient content (Fe, Mg, P and Zn).	
	Gr. III. Saline-Sodic soil	a. Tolerance to salinity levels up to 10-11 dS/m, high sodicity (pH 10) and poor soil structure, high sodium, waterlogging and harsh soil situations b. Tolerance to high salinity and sodicity at seedling and reproductive stage		Ability to perform well in saline-sodic and normal condition b. *(With b same as inland saline category)*	

Table 15. Trait specificity of pipelines: Irrigated

Product pipeline	Type	Basic trait	Essential traits (common for all irrigated pipelines)	Value added trait	Game changing trait
IEME (Irrigated Early/ Mid-early)	Gr. I. (a) Self pollinated (b) Hybrid Gr. II. Aerobic (DSR)	**Self pollinated:** Intermediate amylose (AC: 20-25%), Less Chalky, Soft cooked grain High HRR: 55-65%; MRR> 70% **Hybrid:** CMS: MS, LS grains	**Gr I. Self Pollinated & Hybrid:** **Northern:** Long slender with good elongation (preferred) and high HRR **Eastern:** a. Urban elite- medium/long slender grains with good eating quality b. Rural areas- long bold or short bold for consumption **Southern:** Short and medium slender for consumption (test weight: 12-15g) and long slender for export purpose Kerala and Goa: Pigmented and bold for consumption **Gr II. Aerobic:** N and P use efficiency Fe and Zn deficiency tolerance **Common traits:** Non-Shattering, resistance to vivipary germination,	Lodging resistance, Stable yield	Self-pollinated / Hybrid: Grain Yield of 7-8 t/ha Low GI High Protein/Zn/ Fe Gr 2 Aerobic (DSR): Grain Yield of 5-6 t/ha Low GI High Protein/Zn/ Fe IMTSL: Grain Yield of 8-10 t/ha ILT: HRR: > 65%, Low GI
IMTSL: (Irrigated Medium Transplanted	Gr. I. Self pollinated Gr. II. Hybrid				
ILT: (Irrigated Late Transplanted	Gr. I. Self-pollinated Gr. II. (Hybrid)				
TMDR (Transplanted, medium duration dry season rice)	1. Dry season Rice	**Self-pollinated:** Intermediate amylose (AC: 20-25%), Less Chalky, Soft grain High HRR: 55-65%; MRR> 70% **Hybrid:** CMS: MS, LS grains	Cold tolerance at seedling stage and Terminal heat tolerance (more than 35 °C) at reproductive stage leading to high spikelet fertility and less grain chalkiness	High HRR about 60-65%	High yield of 8-10 t/ha
	2. Boro rice	Early vigour, High yield		High yield of 8-10 t/ha	Lodging resistance particularly to cyclones

Table 16. Trait specificity of Speciality Rice pipelines

Product pipeline	Type	Basic trait	Essential traits (common for all irrigated pipelines)	Value added trait	Game changing trait
Special-ty Rice	Gr. I. Aromatic Grain type	Aroma, GC soft with superior mouth feel and sensory qualities	Short slender: AC 15-18% for *Khichdi*, 18-20% for *Pulao, lemon rice* (Soft GC with ER>1.5) Short bold: AC 4-18% for *kheer/ payasam* AC 10-20% for different types of *peetha* (Soft GC with ER>1.5) Medium: AC 15-18% for *Khichdi;* 18-20% for *Pulao, lemon rice* 20-25% for white rice and fried rice (GC soft) Long grain: AC 20-25%, soft GC and ER>1.6 for white rice	Resistance to BB, Blast and BPH. High HRR	• Semi-dwarf plant type, tolerant to lodging, with higher tillering ability • Suitability for organic cultivation
	Gr. II. Nutri-Rice	High protein rice: Mineral rich rice: Fe>16ppm Zn>20ppm All grain types	High antioxidants	High HRR (>60%). Good taste	• Lodging resistance and high yield
	Gr. III. Industry specific rice/market-specific rice Rice based beverage industry	Round shaped grains with belly chalkiness,	Koshikari type (AC 5-25% depending on the type of beverage to be prepared)	High HRR; industry specific AC, GC and grain type	• Higher yield with product specific quality
	Rice based value added products industry: Snacks: *poha/ chuda*, *muri*, *extruded* products, *evai*, *idiyappam*, *murukku* (chakli) rice-based *vadagam/Vathal,* Noodles, *thupka*, etc. Steamed products, *idli*, *dosa*, *Pitha,* momos, sweets, etc Baking industry: Cake, cookies, etc. Ready to serve product Industry: Soak and eat rice, Noodles, steamed rice, *poha*, *Biryani*, etc. Rice based food supplement industry	Product specific quality features for specific value-added products Specific health beneficial compounds like protein, Vitamins, minerals, anti-oxidant, GABA rich rice	*Poha* / Chuda quality (Like Jaya, Indrayani, Mahamaya) *Idli* quality (Savitri), Mudi quality (Lalat)		
	Gr. IV. Low GI & low grain PA	Low GI < 55.0, High resistant starch and Grain Phytic acid (GPA): <1%	MS, LS and SS grain type with good taste HRR>55%	High yield, lodging resistance,	• Higher protein content, essential amino acids, and antioxidants

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Abbreviations:

Shortend Forms	Expanded Versions
AC	Amylose Content
AG	Anaerobic germination
AGS	Arenchymal Gas Space
AICRIP	All India Coordinated Rice Improvement Project
BB	Bacterial Blight
BPH	Brown Plant Hopper
BS	Brown Spot
CEC	Cation Exchange Capacity
CGMS	Cytoplasmic Genetic Male Sterility
CMS	Cytoplasmic Male Sterility
CS	Coastal Salinity
DSR	Direct seeded Rice
EDS	Early Direct Seeded
EDSDP	Early Direct Seeded Drought Prone
ER	Elongation Ratio
ESP	Exchangeable Sodium Percentage
FS	False Smut
GM	Gall Midge
GABA	Gamma-aminobutyric acid
GI	Geographical Indication
GI	Glycemic Index
GPA	Grain Phytic Acid
GSOD	Germination Stage Oxygen Deficiency
HI	Harverst Index
HRR	Head Rice Recovery
IEME	Irrigated Early/Mid Early
ILT	Irrigated Late Transplanted

IMT	Irrigated Medium Transplanted
IMTD	Irrigated Medium Transplanted Dry Season
LB	Long Bold
LDSDD	Late Duration Semi deep/deep
LPA	Low Phytic Acid
LS	Long Slender
LSD	Late duration Semi-deep/deep
MRR	Milled Rice Recovery
MS	Medium Slender
NE	North East
NEHR	North Eastern Hill Region
NER	North Eastern Region
PA	Phytic Acid
RDSM	Rainfed Direct Seeded Medium
RLSL	Rainfed Late Shallow Lowland
RTV	Rice Tungro Virus
SAR	Sodium Adsorption Ratio
SB	Stem Borer
SB	Short Bold
Sh.B	Sheath Blight
Sh.R	Sheath Rot
SRBSDV	Southern rice black-streaked dwarf virus
SS	Short Slender
TMDR	Transplanted medium duration dry season rice
TPR	Transplanted rice
USDA	United State Department of Agriculture
YSB	Yellow Stem Borer

Direct Seeded Rice

Duration	Category	Value Added Traits	Must Have traits
90 Days	Upland	High N and P use efficiency; Fe and Zn def. tolerance; Nematode resistance	Drought tolerance, Weed competitiveness/ Herbicide Tolerance
110 Days	Early Direct Seeded	High N and P use eff.; Fe and Zn def. tol, Nematode resistance	Drought tolerance, Anaerobic germination, Weed competitiveness/ Herbicide Tolerance
135 Days	Medium Direct Seeded	High N and P use eff.; Fe and Zn def. tol, Nematode resistance	Drought tolerance, Anaerobic germination, Weed competitiveness/ Herbicide Tolerance
>140 Days	Late Direct Seeded	>14 days submergence tolerance, BLB, BPH, Sheath blight, blast, stem borer tolerance, , resistance to vivipary germination	Intermittent Drought Tolerance

Un-favourable Low land

Duration	Category	Value Added Traits	Must Have traits
>135 Days	Rainfed Shallow Lowland	Stagnant Flooding tolerance, BLB, Sheath blight, blast, stem borer tolerance, , resistance to vivipary germination,	Intermittent Drought tolerance, Submergence Tolerance,
>140 Days	Semi-Deep to Deep water	>14 days submergence tolerance, BLB, Sheath blight, blast, stem borer tolerance, resistance to vivipary germination, lodging resistance	Stagnant Flooding tolerance, Kneeing ability, intermittent drought tolerance
>135 Days	Coastal salinity	>14 days submergence tolerance, BLB, Sheath blight, blast, stem borer tolerance, , resistance to vivipary germination	Seedling and reproductive stage Salinity, Stagnant Flooding tolerance,

Irrigated/ Favourable lowland

Duration	Category	Value Added Traits	Must Have traits
110 Days	Early	False smut resistance, Lack of high yielding varieties (>6.0 t/ha), lodging resistance	Non-Shattering, resistance to vivipary germination, **Aerobic:** N and P use efficiency; Fe and Zn deficiency tolerance
135 Days	Medium/ Boro	Lack of very high yielding >7.0 t/ha, lodging resistance,	Seedling Stage Cold tolerance and reproductive stage heat tolerance for **Boro**
>135 Days	Late	False smut resistance, Bakanae disease tolerance, resistance to vivipary germination,	Lodging resistance

Speciality Rice

Duration	Category	Value Added Traits	Must Have traits
>135 Days	Aromatic Short Grain	High HRR, Lodging resistance	Aroma, soft GC with superior mouth feel and sensory qualities
>135 Days	Nuti- Rice	Lodging resistance and high yield	High Protein, minerals rich, antioxidant rich
>135 Days	Industry specific Rice	High HRR with suitable AC/GC requirements	Industry specific traits
>120 - 135 Days	Low GI, Low PA	Lodging resistance, High yield	Low GI and Low PA

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