HR2DC24
Hybrid Rice Development Consortium
ANNUAL MEETING

2024 ANNUAL REPORT

Hybrid Rice Development Consortium
International Rice Research Institute
Los Baños, Philippines

Hybrid Rice Development Consortium (HRDC)

Annual Report 2024

HYBRID RICE DEVELOPMENT CONSORTIUM (HRDC)
Jauhar Ali, Head

EXECUTIVE SUMMARY

This report highlights the recent activities and outlines the future direction of the consortium.

The HRDC Annual Meeting was held on September 25-26, 2024, at the IRRI South Asia Hub located on the ICRISAT Campus in Hyderabad, India (Figure 1 and Appendix 1). The meeting was attended by 68 members on-site, from India, Indonesia, and the Philippines, with an additional 69 members participating online. During the meeting, we welcomed the new HRDC members: New Asia Hi-Tech Seeds Co., Ltd., Myanmar (Platinum member), Trimurti Plant Sciences Private Limited (Silver member), and Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV) (Platinum-Green member). The members visited the fields dedicated to HRDC activities, including seed producibility trials of selected hybrids released in the Philippines, as well as trials conducted by IRRI India (Appendix 2). We invited the HRDC members to visit the seed producibility trials at maturity to fully observe the trials (Appendix 3).

We have organized the follow up workshop on the "***Strategies for the adoption of the hybrid rice technology"*** through the HRDC platform at ICRISAT, Hyderabad on 5 April 2024. This workshop was a continuation of the discussions from the pilot meeting in 2023, focusing on the progress made on the strategies that were defined. It was attended by the members of each working group: Technical Research, Market Demands and Pressures, Policy Funding and Advocacy, Capacity Building and Awareness.

Climate change is expected to significantly impact rice production in many countries across Asia and Africa, with rising sea levels posing a direct threat to the delta regions of Asia within the next decade. During the World Food Forum in Rome (October 15-18), organized by FAO, I raised concerns about the future of global rice production under these changing climatic conditions. I also emphasized our work on arsenic-safe rice inbreds and hybrid varieties.

Scaling up the hybrid rice technology presents a viable solution to combat climate change and enhance food security in Asia and Africa. The adoption of hybrid rice technology can enable many Asian countries to sustain and secure their rice production.

The HRDC is open to collaborating with NARES partners in these regions to ensure that we play a significant role in achieving this goal. Recently, JNKVV joined HRDC to support increased rice production in Madhya Pradesh, India, with special funding from the Ministry of Agriculture and Farmer's Welfare, Bhopal.

Figure 1. HRDC Annual Meeting at IRRI South Asia Hub, ICRISAT Campus, Hyderabad, India.

This annual report presents the updated activities on the three high-priority projects initiated under the revitalized HRDC program:

Project A1: Developing elite parental lines targeting market requirements for South Asia and Africa;

Project A2: Developing elite parental lines targeting market requirements for Southeast Asia; and

Project A3: The collective evaluation of F_1 hybrids towards breeding of highly adaptable parental lines and F_1 hybrids for different market segments

To address the emerging markets in Africa, we began sharing parental lines and hybrids. The HRDC will carefully assess the materials generated from its major market-driven pipelines and identify suitable materials appropriate for this region. All HRDC members interested in these new market segments in Africa can write to the HRDC Secretariat for help in catering to their needs.

Under the One NARES network, for 2024, we have nominated 29 hybrids (10 early maturing, 19 medium maturing) that were tested in several locations (Appendix 4). From these hybrids, four, five, and two were selected and advanced to the Stage 2 DEMS-R, DELS-I, and TEMS-I pipelines, respectively. We await the results of the 2024 One NARES network trials shortly in April 2025. We have started the activities at IRRI Hyderabad Breeding Hub in multiplying HRDC materials and distributing them locally. We demonstrated the hybrid seed producibility of 3t/ha of the top-performing hybrids (Mestiso 68 and Mestiso 89) in the target seed production environments in Telangana region (South Asia) to create opportunities for licensing. These seed production sites were visited by the HRDC members.

PROJECTS A1 AND A2: DEVELOPING ELITE PARENTAL LINES TARGETING MARKET REQUIREMENTS FOR SOUTH ASIA, AFRICA, AND SOUTHEAST ASIA

Market segments for Southeast and South Asia and Africa were established in 2019, with the support of HRDC members, which serves as the initial guide for targeted product profiling. Under the OneRice breeding strategy of the Rice Breeding Innovation, the hybrid rice breeding program will focus on five key segments (Table 1).

To enhance the parental lines, the source nursery (SN) is organized into heterotic pools according to market requirements. Crosses between elite B x B and R x R lines are made within each pool based on these market preferences, ensuring the pools remain distinct and aligned with specific market demands.

In 2024, there were 367 breeding lines in the source nursery, which consisted of elite lines from various breeding groups at IRRI and our NARES partners. Aside from these materials, there are also advanced lines from adverse environments, such as direct-seeded, drought, and saline conditions. These lines were genotyped using 1k RiCA to determine their value-added traits and identified their heterotic group.

In 2024, 51 B x B crosses were made within the best heterotic group during both the dry and wet seasons. The parental lines for B x B combinations were selected based on the market segments of South Asia, Southeast Asia, and Africa. The segregating populations from these crosses were then sent to RGA for generation advancement until fixation.

For phenotypic evaluation and selection, 1,040 F_6 plants from 2 B x B populations and 3,120 F_6 plants from 6 R x R populations were planted. From these, 599 individual plants from these segregating populations were selected. Once these are fixed, we will share more promising lines with our members.

In 2025, testcrosses will be conducted using the selected restorer lines with a set of testers. Selected high GCA B lines will be categorized based on the five market segments using the 1k RiCA data and the Intertek Hybrid Rice panel. The materials will be ranked from best to worst by considering the value-added genes. The best ranking high yielding and high GCA B lines with superior plant type traits will be used for backcrossing to the most promising and stable IRRI CMS lines to develop new sources of better and improved CMS lines.

The testcrossed materials will be evaluated under combining ability trials to assess their general and specific combining abilities (GCA and SCA). This data will then be used to initiate a hybrid seed production cycle to organize the Stage 1 (OYT) and Stage 2 (AYT) trials.

Based on the trial results, 20 elite hybrids will be identified for inclusion in the One NARES network trials of the Rice Breeding Innovation, with over 40 sites from the 120 available sites worldwide. Additionally, we plan to establish another set of IRRI hybrid rice trials through the HRDC network. This will involve comparing market-oriented IRRI hybrids with HRDC member hybrids in their respective target geographies. This set up allows members to evaluate IRRI hybrids against their own under local conditions, creating more opportunities to license IRRI-bred hybrids.

Seed production of the top hybrids will be demonstrated, both at IRRI Headquarters and IRRI Hyderabad Breeding Hub for members to observe. Finally, the most promising hybrids will be submitted to the National Yield Trials in key target countries, including India, Bangladesh, Indonesia, and the Philippines.

Table 1. Hybrid Rice market segments, active breeding pipelines, and product concepts

Center	Crop	Market segment	Pipeline	Market segment description	Key Traits (Details in product concept sheet)	Pipeline size	Agro-ecology (Hydrological topography)	Countries in the Market Segment and hectares targeted in each country (AGGRi priority geogrphies in red bold)	Hectares targeted (000' ha)	Reference/ Benchmark Varieties
IRRI	Rice	TEMS-I	EMS-I	Transplanted early duration medium slender soft grain rice for irrigated ecosystem in India (Punjab, Haryana, Uttar Pradesh, Bihar)	Agronomic: Early duration, High yield, Lodging resistance Grain quality: Medium slender, High HRR, intermidiate amylose, Low chalk, aroma (preferred), high nutritive value (preferred) Biotic stresses: Blast (leaf and neck), brown spot, BLB, BPH, stem borer Abiotic stresses: Drought (reproductive), Heat, inland salinity/ sodicity	0.5X	Irrigated lowland,photoperiod-insensitive	India (6.6m Ha, North and Eastern India (UP and Blhar)	6,600	Pusa 44, PR 126 MTU1010 (need a little earlier variety in Eastern India).
IRRI	Rice	DELS-I	ELS-I	Direct seeded, early duration, long slender soft grain rice for irrigated ecosystems in northern India (Punjab, Haryana, western UP), Cambodia, Thailand, Malaysia, Malawi, Zambia	Agronomic: Early duration, High yield, Early emergence and vigor, Lodging resistance Grain quality: Long slender, High HRR, intermidiate amylose, Low chalk, aroma (preferred), high nutritive value (preferred) Biotic stresses: Blast (leaf and neck), brown spot, BLB, BPH, Stem borer, Nematode, RYMV (Africa) Abiotic stresses: Drought (seedling and reproductive), Heat, inland salinity/ sodicity, iron toxicity (Africa), Anaerobic germination	0.5X	Irrigated lowland, Direct seeded	India (Northern India - 0.87m Ha), Cambodia (0.7m Ha), Thailand (2.2m Ha), Malaysia (0.5m Ha), Malawi (.07) and Zambia (.023)	4,365	India: PR126, MTU1010 Cambodia: Phaka Rumdoul , Thailand: KDML105, RD6, RD10 - Malaysia: MRQ 74 Malawi: Nunkire, Nerica 4. Zambia: ITA 230, Longe 1.
IRRI	Rice	TMeLS-I	MeLS-I	Transplanted medium duration, long slender, soft grain type for irrgated rice grown in parts of SE Asia (Philippines, Indonesia,) and Eastern & Southern Africa (Tanzania, Uganda, Kenya)	Agronomic: Medium duration, High yield, Lodging resistance Grain quality: Long slender, High HRR, intermediate amylose, Low chalk, aroma (preferred), high nutritive value (preferred) Biotic stresses: Blast (leaf and neck), brown spot, BLB, BPH, sheath blight, Stem borer, RYMV (Africa), Tungro (SEA) Abiotic stresses: Submergence (few areas) Heat, salinity (few areas)	0.5X	Irrigated lowland and favourable rainfed lowand	Kenya (.018m Ha), Tanzania (.009m Ha), Republic of Congo, Uganda, Other ESA countries, Philippines (1.5 m Ha), Indonesia (8.7m Ha),	10,715	Tanzania: Supa, Saro 5, TXD 306 Kenya: Komboka, Basmati 370 Philippines: NSIC Rc 222 Indonesia: Ciherang, Ciherang Sub1),
IRRI	Rice	DMeLS-I	MeLS-I	Direct seeded, medium duration, long slender, soft grain type rice grown in irrigated areas in the Philippines and Mozambique.	Agronomic: Medium duration, High yield, Early emergence and vigor, Lodging resistance Grain quality: Long slender, High HRR, intermidiate amylose, Low chalk, aroma (preferred), high nutritive value (preferred) Biotic stresses: Blast (leaf and neck), brown spot, BLB, BPH, Stem borer, Nematode, RYMV (Africa), Tungro (SEA) Abiotic stresses: Drought (seedling and reproductive), Heat, inland salinity/ sodicity, iron toxicity (Africa)	0.5X	Irrigated lowland	Mozambique, Philippines	1,679	Mozambique: Tchupa, Makasane, Philippines: NSIC Rc 222
IRRI	Rice	TLaMF-I	LaMF-I	Transplanted, med-late duration, medium slender, firm and dry grain type for irrigated rice growing in Bangladesh (North and central) during Boro season	Agronomic: Medium duration, High yield, Lodging resistance Grain quality: Medium slender, High HRR, high amylose, Low chalk, aroma (preferred), high nutritive value (preferred) Biotic stresses: Blast (leaf and neck), brown spot, BLB, BPH, sheath blight, Stem borer, Abiotic stresses: Cold (seedling and reproductive) Submergence (some areas), Heat, salinity (some areas)	0.5X	Irrigated lowland	Bangladesh (2.89m Ha)	2,890	BRRI Dhan 29 (Haor, Bill areas), BRRI Dhan 28 (Plain lands)
IRRI	Rice	TLaSF-I	LaSF-I	Transplanted, Late maturing, Small grain, firm texture for irrigated lowland	Agronomic: Late duration, High yield, Lodging resistance Grain quality: Short slender, High HRR, intermediate amylose, Low chalk, aroma (preferred), high nutritive value (essential) Biotic stresses: Blast (leaf and neck), BLB, BPH, sheath blight, Stem borer, Abiotic stresses: Anaerobic germination	1.0X	Irrigated lowland	India (7.84 Ha)	7,843	Swarna, BPT5204, Telangana Sona, TNRH-174 (hybrid)

The elite-by-elite breeding strategy for genomic selection is being implemented across all major IRRI rice breeding pipelines of early-, medium-, and long-duration rice, covering nine market segments (Figure 2). Hybrid rice breeding has its own six overlapping market segments.

Currently, the focus is on breeding female parental lines tailored to each market segment. IRRI's hybrid breeding efforts are dedicated to developing CMS lines for each market segment, incorporating high combining ability and hybrid seed producibility traits. The hybrid rice program will utilize the inbred lines from the early, medium, and late pipelines as male parents with restorer genes.

Advanced materials from these nine inbred breeding pipelines were shared (252 lines in 2024 alone) each year with the hybrid rice breeding program (Figure 2). After genotyping with 1k RiCA, these materials will be classified under heterotic pools. These materials will bring the required diversity within the pools, specifically targeting market requirements. The genetic gains achieved in these breeding pipelines will support the hybrid rice breeding program.

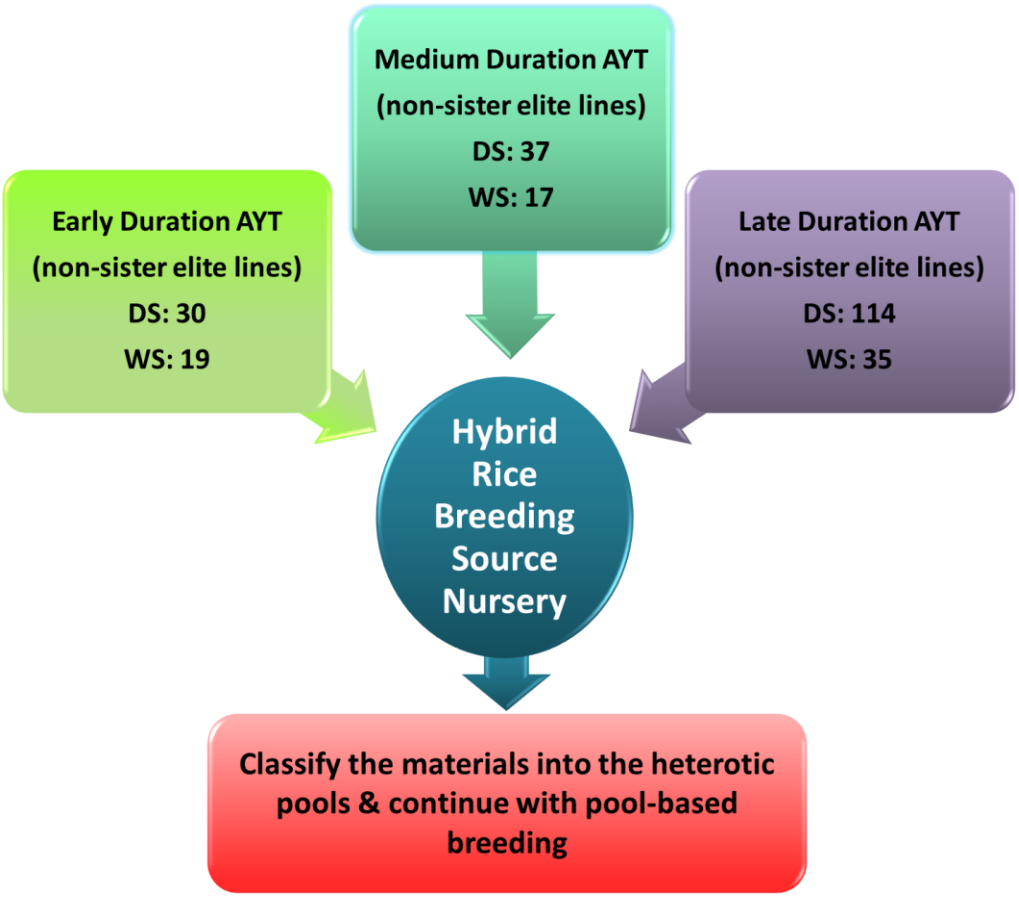

Figure 2. Flow of OneRice breeding strategy materials to the hybrid rice breeding program.

The development of elite parental lines through the OneRice breeding strategy for South Asia markets will be helpful for targeting specific market segments based on key traits, which includes duration, grain quality, biotic and abiotic stress resistance. Likewise, parental breeding for the market requirements for Southeast Asian countries such as Indonesia, the Philippines, and Vietnam will be achieved.

IRRI will be focusing on specific market segments where hybrid rice technology can offer the most significant advantages. These can be defined by environmental conditions, where specific stresses will be addressed (drought, salinity, submergence, etc.). Farming systems should also consider whether a specific region is mostly irrigated or rainfed, and where the hybrids outperform conventional varieties.

The traits for hybrid seed production are common for South and Southeast Asian markets, which include seed reproducibility of >3.0 t/ha, higher outcrossing traits, narrow flowering differences, and tolerance to fluctuating climatic conditions. By conducting hybrid rice trials with HRDC members in East and Southern Africa, we can effectively address the market requirements by utilizing the available HRDC materials.

ACTIVITIES FOR PROJECTS A1 AND A2

- We have successfully introgressed the NSIC Rc 222 traits, such as rice blast gene (*Pita*), rice Tungro virus gene (*tsv1*), and brown planthopper gene (*BPH3*). Currently, the generated A, B, and R lines that possess all three introgressed genes are being evaluated and upscaled. Two of the R lines were shared with all the members.

- Genetic purification and initial seed increase of 362 high priority CMS/B/R lines were conducted using phenotypic evaluation and various SNP panels (1k RiCA, hybrid SNP panel). The purification experiments were carried out in a stepwise manner depending on the purity of each material, classified as Stage 1, 2, and 3 with initial seed increase occurring during Stage 3. *Rf4* and *WA-CMS* molecular markers served as the primary criteria for ensuring high-quality seed production and maintaining the genetic purity of the lines (Table 2 and Figure 3).

- Fifty-one B x B crosses were made in 2024. Currently, our primary focus is to develop female parental lines for different market segments. These crosses are strategically designed based on the heterotic pools and specific target traits required for each market segment.

- These materials in RGA are at the F5-F6 stage: 84 advanced materials, 44 B x B and 40 R x R. This will certainly accelerate the ongoing efforts to provide improved R and new CMS/B pairs for various market needs.

- The market segment requirements will be the key driver for the OneRice breeding strategy. Planting methods (both direct-seeded and transplanted rice), plant growth duration (<100 d as very early, 110–120 d as early, 120–130 d as medium, >130 days late), grain size, and quality traits including amylose content, gel consistency, and gelatinization temperature are important traits that need to be considered. The breeding of B and R lines with a focus on resistance to biotic and abiotic stresses, higher outcrossing traits, and combining ability is equally vital to our objectives.

- We started the conversion of maintainer lines with high general combining ability (GCA) and outcrossing traits into new CMS lines. These lines will have high amylose (22–26%) for South Asia and Africa and medium amylose (17–22%) for Southeast Asia.

- Elite parental lines are being used in testcrossing activities to identify heterotic rice hybrids. These hybrids are evaluated and screened for key traits such as growth duration, grain quality, pest and disease resistance, and abiotic stress resistance to meet market demands in key countries in South and Southeast Asia and Africa. In 2024, 265 hybrid combinations were selected based on phenotypic scores and/or yield compared to the hybrid check from the combining ability trial (CAT). Sixty-seven of these were initially forwarded for hybrid seed production.

- Fifteen restorers with value-added traits, two restorers with the NSIC Rc 22 traits, 4 false smut resistant lines, and 1 false smut susceptible line were shared with the HRDC members (Tables 3).

Table 2. Number of lines tested and genotyped for purity testing and germplasm characterization.

Purpose	No. of lines tested	SNP panel used
Purity testing	356	Hybrid panel (Intertek)
Germplasm characterization	1,581	Hybrid panel (Intertek) + 1k RiCA

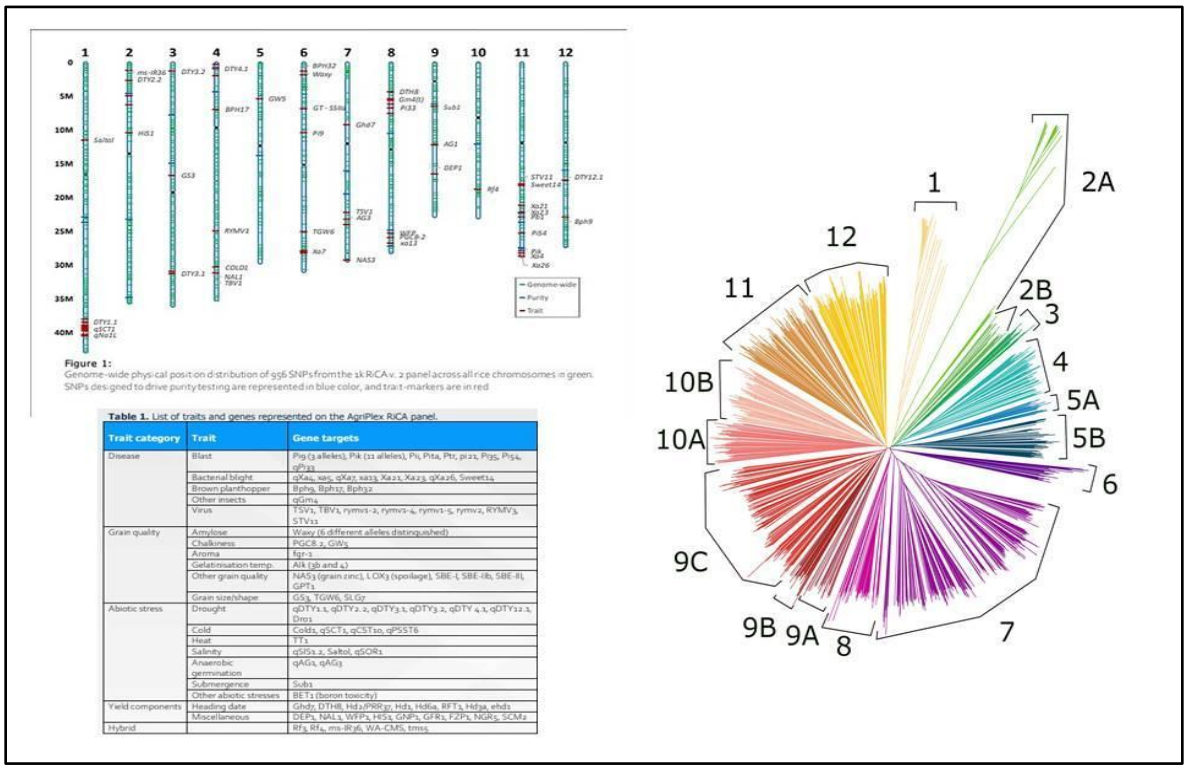

Figure 1:
Genome-wide physical position distribution of 956 SNPs from the 1k RiCA v. 2 panel across all rice chromosomes in green. SNPs designed to drive purity testing are represented in blue color, and trait-markers are in red

Table 1. List of traits and genes represented on the AgriPlex RiCA panel.

Trait category	Trait	Gene targets
Disease	Blast	Pi9 (3 alleles), Pik (11 alleles), Pii, Pi1a, Ptr, pi21, Pi35, Pi54, qPi33
	Bacterial blight	qXa4, xa5, qXa7, xa13, Xa21, Xa23, qXa26, Sweet14
	Brown planthopper	Bph9, Bph17, Bph32
	Other insects	qGm4
	Virus	TSV1, TBV1, rymv1-2, rymv5-4, rymv1-5, rymv2, RYMV3, STV11
Grain quality	Amylose	Waxy (6 different alleles distinguished)
	Chalkiness	PGC8.2, GW5
	Aroma	fgr-1
	Gelatinisation temp.	Alk (3b and 4)
	Other grain quality	NAS3 (grain zinc), LOX3 (spoilage), SBE-I, SBE-IIb, SBE-IIJ, GPT2
	Grain size/shape	GS3, TGW6, SLG7
Abiotic stress	Drought	qDTY1.1, qDTY2.2, qDTY3.1, qDTY3.2, qDTY 4.1, qDTY12.1, Dro1
	Cold	Cold1, qSCT1, qCST10, qPSST6
	Heat	TT1
	Salinity	qSIS1.2, Saltol, qSOR1
	Anaerobic germination	qAG1, qAG3
	Submergence	Sub1
	Other abiotic stresses	BET1 (boron toxicity)
Yield components	Heading date	Ghd7, DTH8, Hd2/PRR37, Hd1, Hd6a, RFT1, Hd3a, ehd1
	Miscellaneous	DEP1, NAL1, WFP1, HS1, GNP1, GFR1, FZP1, NGR5, SCM2
Hybrid		Rf1, Rf4, ms-IR36, WA-CMS, tms5

Figure 3. High-throughput genotyping (HTPG) works for the forward breeding, genetic purity testing, and germplasm characterization of hybrid breeding materials. Chromosome map and table of traits courtesy of Agriplex RiCA v4

Table 3. List of parental lines shared in 2024.

S. No.	Designation	DTF	DTM	Plant height (cm)	Tiller number	Grain shape	Grain size	Value-added genes								
								BLB	BPH	Blast	Tungro	AG	Salinity-seedling	Drought (reproductive)	Amylose	Chalk
1	IR 96479-23-1-1-1-2-1-1-1	102	132	105	16	M	M	XA26_1,XA4_2		PI33_2,PI33_3	TSV1_UM			DTY2-2_1,DTY3-2-SWARNA_1,DTY3-2-IR64_1,DTY4-1_2,DTY12-1_2	WX-OP	
2	IR 96542-86-4-1-1-1-2-1-1	100	130	111	17	M	M	XA26_1,XA4_2 {H}		PI33_1,PI33_2,PI33_3				DTY2-2_1,DTY4-1_2	WX-OP	
3	IR 98153-15-1-1-3-1-1-1	100	130	100	12	S	M	XA26_1,XA4_2		PI33_2,PI33_3,Pi2/Piz {H},Pi2/Piz,Pik,Pik		AG3_1,AG3_2		DTY12-1_2	WX-OP,WX-A_GROUP,Waxy	
4	IR 98201-16-1-2-1-1-1-1	107	137	105	19	M	M	XA26_1				AG3_1,AG3_2	SALTOL-ARO	DTY4-1_2	WX-OP,WX-INT	
5	IR 98206-46-2-1-2-1-1-1	102	132	97	10	M	M	XA26_1		PI33_2,PI33_3,Pi2/Piz {H},Pi2/Piz {H},Pii,Pik,Pik,Pik,Pik	TSV1_UM {H}	AG3_1,AG3_2,AG1 {H}	SALTOL-ARO	DTY4-1_2	WX-OP,WX-A_GROUP,WX-A-RC222,Waxy	
6	IR 101999-7-1-1	95	125	97	10	M	M	XA26_1,XA4_2		PI33_2,PI33_3,Pik,Pik			SALTOL-AUS	DTY12-1_2	WX-OP	
7	IR 112867-39-2-1	98	128	106	18	M	M	XA26_1,XA4_2				AG3_2	SALTOL-ARO,QSES1-2_1	DTY12-1_2 {H}	WX-OP,WX-INT	
8	IR 112871-18-1-1	102	132	107	14	M	M	XA26_1,XA4_2		Pik,Pik		AG3_1,AG3_2,AG1	SALTOL-AUS		WX-OP,WX-INT,Waxy	
9	IR 101921-BK-BK-BK-10-1-1	102	132	102	15	M	M	XA26_1		Pii		AG3_1,AG1	SALTOL-ARO,QSES1-2_1		WX-OP	Chalk5
10	IR 112924-37-1-1	98	128	101	13	M	M	XA26_1		Pita,Ptr		AG1	QSES1-2_1,QSES1-2_2	DTY4-1_2,DTY12-1_2	WX-OP,WX-INT,Waxy	
11	IR 101922-BK-BK-BK-4-1-1	98	128	108	13	M	M	XA26_1		PI33_2,PI33_3		AG3_1,AG3_2	QSES1-2_1		WX-OP	Chalk5
12	IR 98206-13-1-1-1-3-1-1	102	132	97	14	M	M	XA26_1,XA4_2		PI33_1,PI33_2,PI33_3,Pik,Pik	TSV1_UM	AG3_1,AG3_2,AG1_1,AG	SALTOL-ARO,QSES1-2_1	DTY2-2_1,DTY2-2_3	WX-OP	
13	IR 96542-120-1-1-1-1-2-1-1	109	139	111	17	M	M	XA26_1		PI33_1,PI33_2,PI33_3			SALTOL-ARO,QSES1-2_1	DTY4-1_2	WX-OP	Chalk5
14	IR 96572-32-3-1-1-1-1-1-1	97	127	97	14	M	M	XA26_1,XA4_2		Pik,Pik		AG3_1,AG3_2	SALSALTOL-AROOL-ARO {H}	DTY2-2_3,DTY12-1_2	WX-OP,WX-A_GROUP,WX-A-RC222,Waxy	Chalk5
15	IR 101999-22-1-1	102	132	85	16	M	M	XA26_1		PI33_2,PI33_3,Pik,Pita		AG1	QSES1-2_1	DTY1-1_1	WX-OP,WX-INT,WX-A-RC222,Waxy	Chalk5
16	IR 143460:1-1-114-1-2									Pik,Pik,Pita	TSV1_UM	AG3_1,AG3_2		DTY2-2_1,DTY2-2_3	WX-OP,WX-A_GROUP,WX-A-RC222,Waxy	Chalk5
17	IR 143468:5-1-4-3									PI33_2,PI33_3,Pik,Pik,Pita	TSV1_UM	AG3_2		DTY2-2_1,DTY3-2-SWARNA_1,DTY3-2-IR64_1	WX-OP,WX-A_GROUP,WX-A-RC222,Waxy	
18	IR15A3804															
19	IR 86555-3-1-1-1-1-3-2-1-1							XA26_1,XA4_2		PI33_2 {H},PI33_3 {H},Pik,Pik,Pita {H}	TSV1_UM {H}	AG1_1 {H},AG1 {H}	SALTOL-AUS,SALSALTOL-AROOL-ARO {H}	DTY2-2_1,DTY3-2-SWARNA_1 {H},DTY3-2-IR64_1 {H},DTY12-1_2 {H}	WX-OP	Chalk5 {H}
20	GSR IR20-4-Y3-L5-Y1 (IR 110897-18-5-5)							XA26_1,XA4_2		Pi2/Piz {H},Pi2/Piz,Pii,Pita		AG3_1,AG3_2,AG1		DTY12-1_2	WX-OP,WX-A_GROUP	Chalk5
21	GSR IR22-10-Y3-Y2-L1							XA26_1,XA4_2		PI33_1			SALTOL-ARO	DTY3-2-SWARNA_1,DTY3-2-IR64_1,DTY4-1_2,DTY12-1_2	WX-OP,WX-INT	
22	GSR IR2-8-Y5-SU1-L2							XA26_1,XA4_2				AG3_2		DTY1-1_1,DTY12-1_2	WX-OP,WX-A_GROUP,WX-A-RC222	

PROJECT A3: COLLECTIVE EVALUATION OF F_1 HYBRIDS TOWARD BREEDING OF HIGHLY ADAPTABLE PARENTAL LINES AND F_1 HYBRIDS FOR DIFFERENT MARKET SEGMENTS

The top performing IRRI hybrids will be nominated for Stage 1 testing within the One NARES network, encompassing over 50 locations. The trials include five global checks and 5 local checks, facilitating the identification of promising IRRI hybrids and enabling effective comparisons against existing hybrids. The trial details and layout are shown in Figure 4.

The HRDC will analyze all data, and the findings will be presented to HRDC members during the Annual Meeting. The most promising HRDC hybrids will then be nominated into the national trials for potential release and licensing on a first come, first served basis.

In 2024, we nominated 29 hybrids (10 early maturing, 19 medium maturing) to the Stage 1 One NARES Testing, which were tested in several locations (Appendix 4). Currently, we are awaiting the results of the four (DEMS-R), five (DELS-I) and two (TEMS-I) hybrids that were selected and advanced to the 2024 Stage 2 NARES Trials.

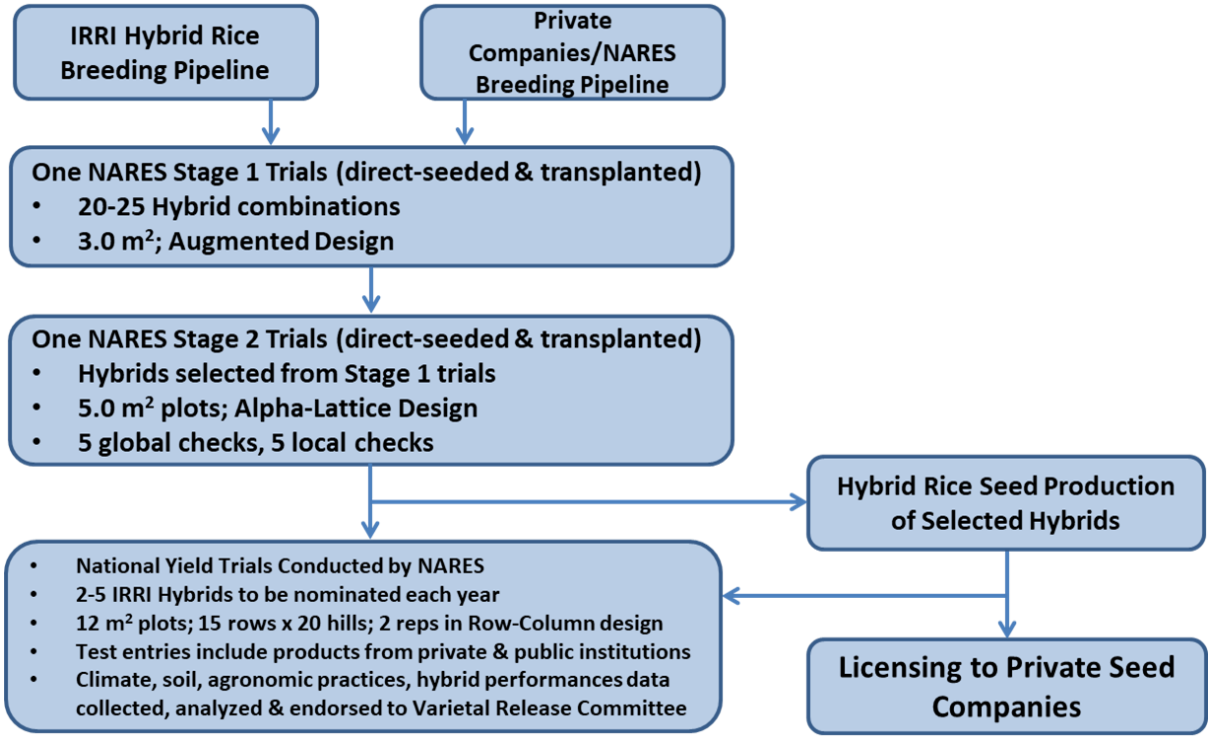

Figure 4. Schematic diagram for the evaluation of hybrids in the One NARES testing toward breeding highly adaptable parental lines and F_1 hybrids for different market segments.

ACTIVITIES

- The Stage 1 Trial had 288 total entries, the Stage 2 Trial had 24 total entries in 2024, and the Stage 2 puddled DSR trial had 24 entries.
- The combining ability trials (CAT) had total entries of 1400 (4 sets), while the Testcross nursery had 1296 entries. Hybrid combinations from these trials that have demonstrated superior performance compared to the hybrid checks will be forwarded for seed production for further testing.
- The best hybrids and parental lines identified from these trials will be shared with all private and public members of the consortium for further testing and evaluation.
- Five hybrids were shared for free with all members in 2024 (Table 4). All HRDC members are requested to submit evaluation data on these hybrids to the HRDC Secretariat.
- The trial results from the members were included.

Table 4. List of hybrids provided to HRDC members in 2024.

S. No.	Designation	DTF	DTM	Plant height (cm)	Tiller number	Amylose (%)	Milled rice (%)	Head rice (%)	Grain shape	Grain size
1	IR 138746H	80	110	92	13	20.8	72.6	60.2	L	S
2	IR 139358H	90	120	120	15	22.3	72.0	61.3	L	S
3	IR 138980H	85	115	120	15	24.1	71.8	50.0	L	S
4	IR 138981H	90	120	111	14	24.0	70.5	52.4	L	S
5	IR 139056H	81	111	125	13	24.8	74.0	60.5	L	S

In the 2024DS Stage 1 trial, highly significant differences in yield were observed (F Value of 3.20 with a Pr>F of 0.0061), with yields ranging from 1.16 to 12.8 t/ha^{-1}. The coefficient of variation (CV = 19.0725%), R-Square value (0.1772), and heritability (0.71) collectively suggested a good fit for the yield model. Best Linear Unbiased Predictions (BLUPs) were obtained using Bioflow (Figure 5). The top performing hybrid was IR 156277H, with a 55.91% yield advantage over the best hybrid check.

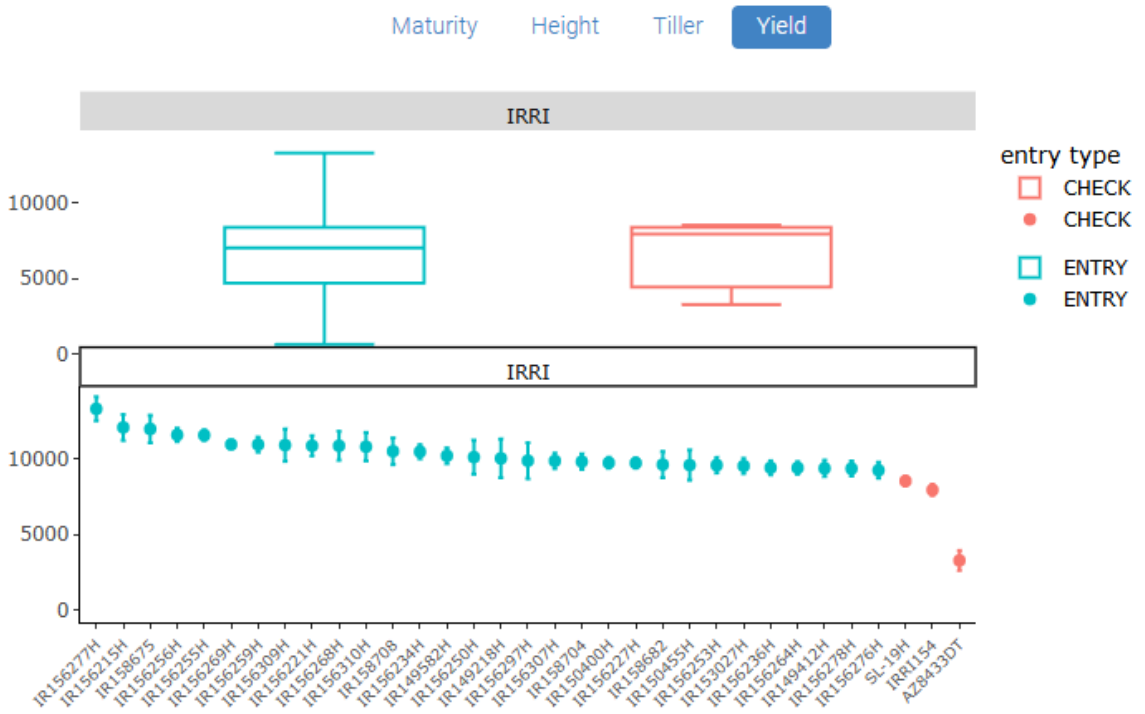

Figure 5. Yield estimates of hybrid entries utilizing Bioflow.

The data analysis of the Stage 2 trial in 2024DS, under transplanted-irrigated condition, showed no significant differences among the test entries (F Value of 1.20, Pr > F of 0.3562). The CV was 7%, the grand mean was 8.10 t/ha, R-Square was 0.3447, and heritability was 0.39 (Figure 6).

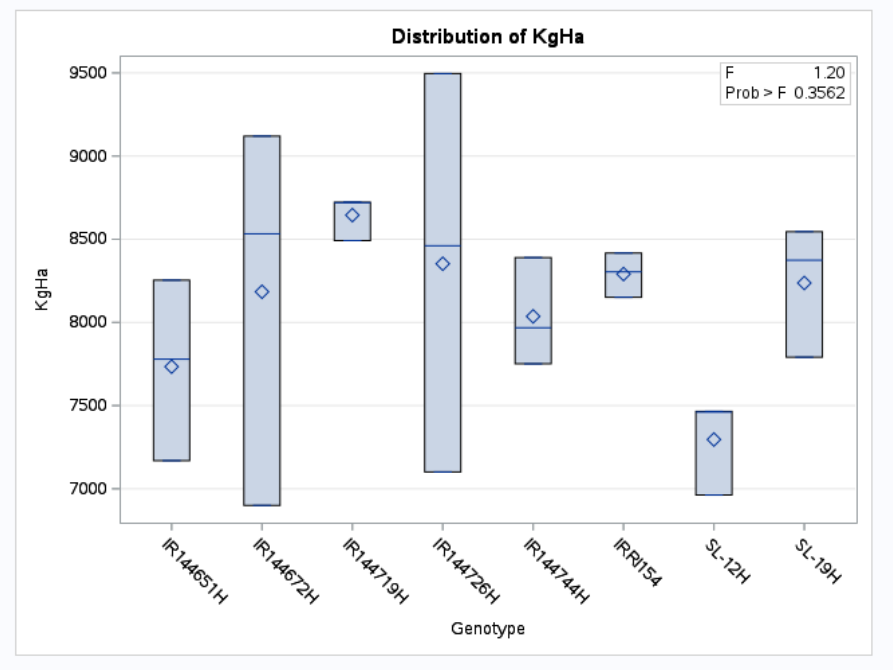

Figure 6. Yield estimates of hybrids in the Stage 2 trial.

Hybrids were also tested under puddled DSR conditions. The statistical values, including R-Square (0.8419), CV (7.51%), F Value (5.33**), and heritability (0.84), indicate a strong model fit for yield performance (Figure 7). The yield ranged from 5.71-10.64 t/ha (Figure 8). The highest yielding test entry, IR145563H, gained 10.64 t/ha in 109 days, with 98.29 productivity per day.

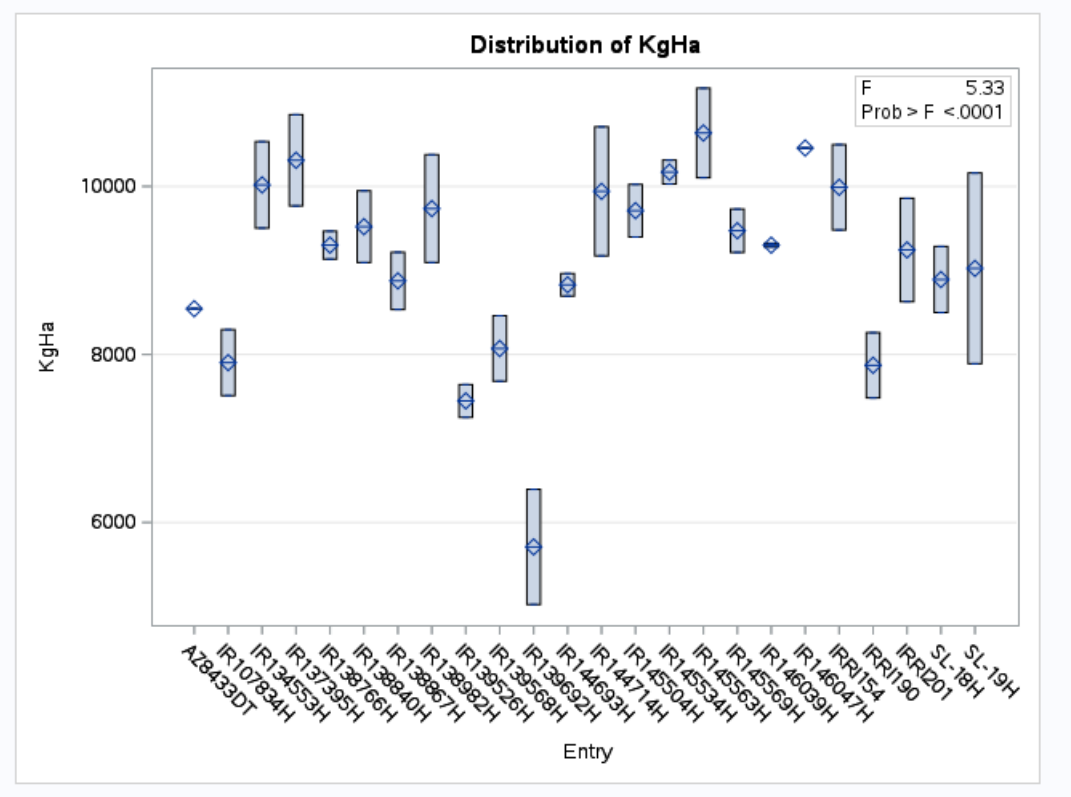

Figure 7. Yield distribution of hybrids tested under puddled DSR.

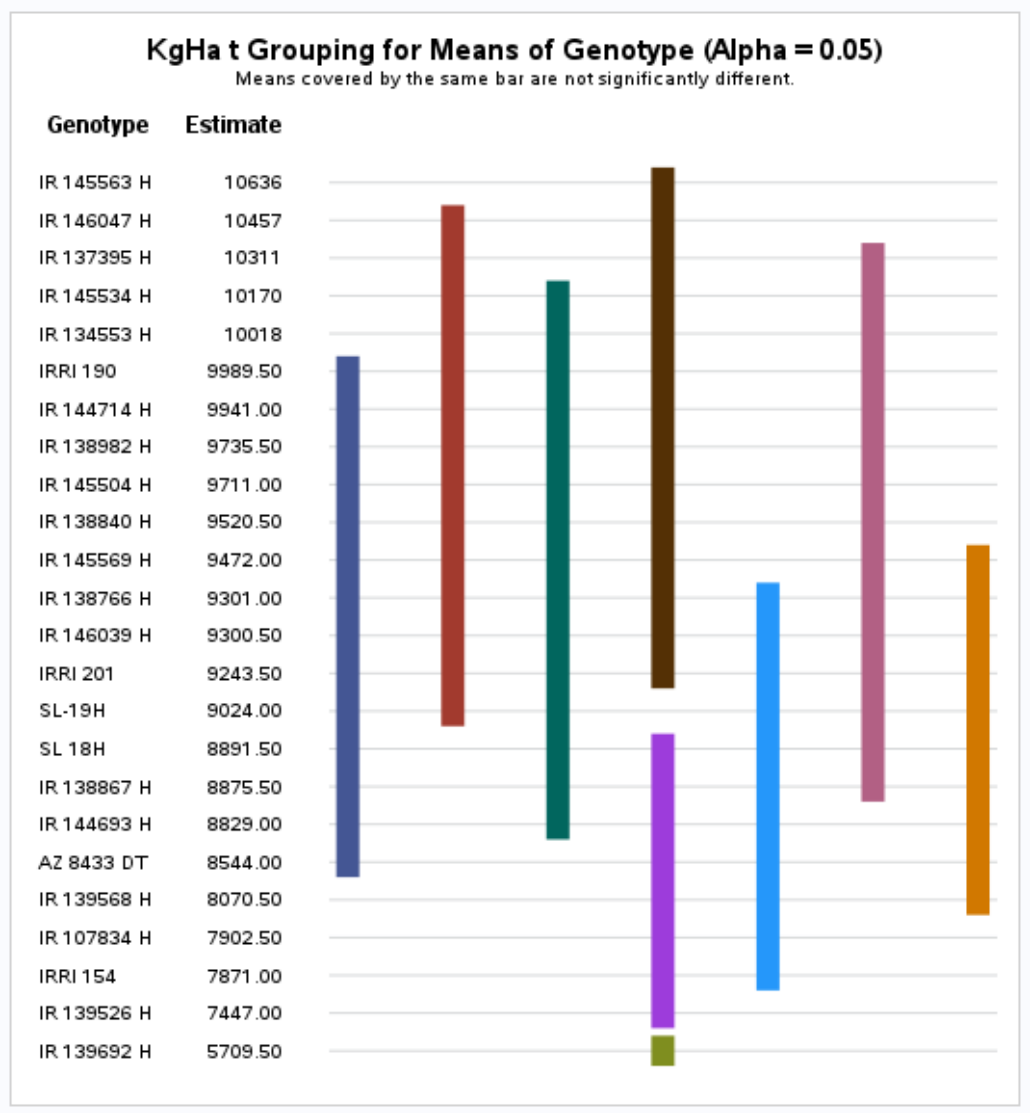

Figure 8. Mean comparison of hybrids tested under puddled DSR 2024DS.

Value Seeds 2024 Hybrid Trial

The evaluation of four IRRI rice hybrids with 2 checks in 2024 revealed that IR138982H and IR138840H outperformed other test entries in yield, maturity and grain quality traits (Table 5). IR138982H showed better agronomic performance with the highest grain yield of 6.87 t/ha with a significant yield advantage of 29% over Faro 44 and 46% over Faro 66. Hybrid entries demonstrated significant variability in grain yield, maturity and grain quality, with consistent performance advantages over the checks.

Table 5. Mean performance of four rice hybrids and two checks 2024 cropping season from Value Seed trial.

Designation	DTF	D50% Flw	Plant height (cm)	Panicle length (cm)	Panicle no./tiller	Tiller no./hill	D85% Mat	Grain length (mm)	100 GW (g)	GYld (t/ha)	Adv Over Faro 44	Adv Over Faro 66
IR138867H	82.00	90.33	81.53	22.00	65.67	13.13	115.33	8.10	219.80	5.21	-2.25	11.09
IR138840H	78.00	85.67	87.67	22.53	66.67	13.33	113.67	8.44	223.96	6.10	14.45	30.06
IR138982H	84.00	96.00	87.27	23.00	65.33	13.07	112.33	8.54	247.66	6.87	28.89	46.48
IR138758H	78.00	90.00	68.20	19.67	41.00	8.20	118.33	8.23	177.69	4.18	-21.58	-10.87
Faro 44	89.67	104.67	88.80	25.80	59.67	11.93	138.00	8.32	243.03	5.33	0.00	13.65
Faro 66	87.33	98.67	83.20	21.33	54.00	10.80	125.00	7.97	232.40	4.69		0.00
MS Error	7.03	13.12	8.76	3.10	235.19	9.41	20.16	0.04	239.33	0.87		
CV	3.19	3.84	3.58	7.87	26.12	26.12	3.73	2.39	6.90	17.31		

Advanta Enterprises Limited 2024 Hybrid Trial

In Kharif 2024, Advanta tested five IRRI hybrids with 2 checks across 5 locations in India (Karnal, Barabanki, Ranchi, Raipur & Hyderabad). Figure 9 presents the boxplot illustrating the distribution of predicted yield values across these five locations.

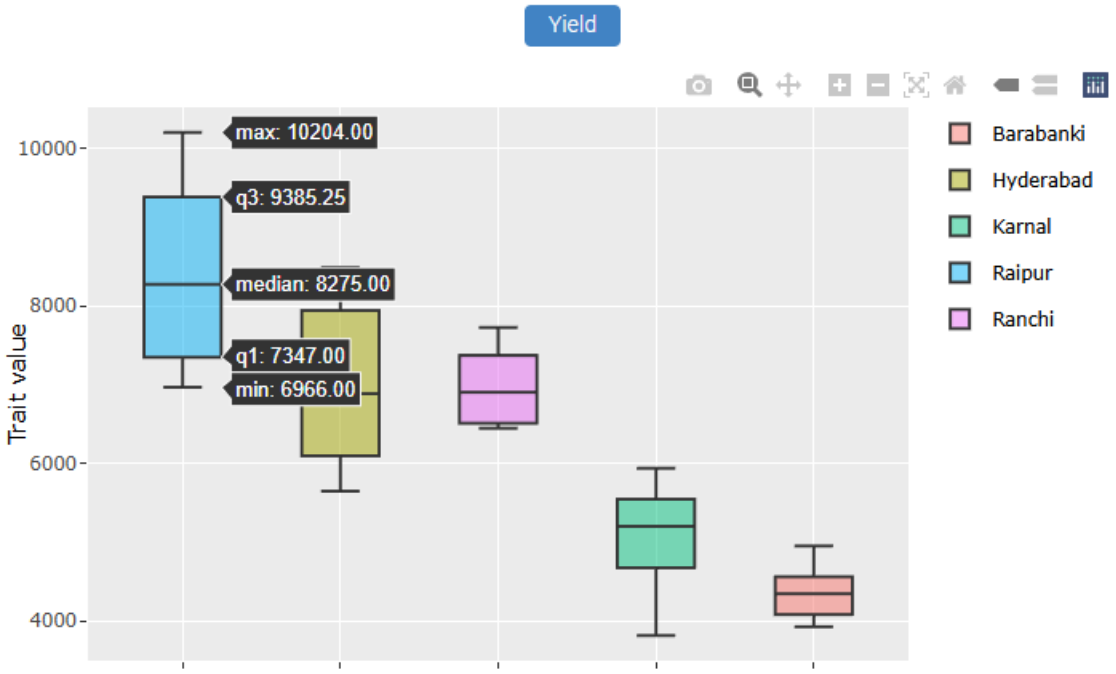

Figure 9. Boxplot of predicted yield values in 5 location trials of Advanta.

Seed Co International

Seed Co International tested 10 IRRI hybrids across three locations in Malawi (Lifuwu, Nazolo & Domasi). Analysis of variance for grain yield (Table 6) showed no significant differences among test entries, though location was significant. The mean grain yield at Nazolo was significant over the other two locations (Figure 10). There was also no significant interaction between genotypes by location.

Average yield ranged from 5.00 t/ha (SCO P06) to 6.83 (IR139010H) t/ha. R-square was 0.52208, the CV was 18.41%, with a grand mean of 6.23 t/ha. Figure 11 shows the boxplots of the distribution of predicted grain yield values across different locations.

Table 6. ANOVA of grain yield from Seed Co International in Malawi.

Dependent Variable: GYIELD

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	44	56023336.3	1273257.6	0.97	0.5435
Error	39	51284344.7	1314983.2		
Corrected Total	83	107307681.0			

R-Square	Coeff Var	Root MSE	GYIELD Mean
0.522081	18.41199	1146.727	6228.155

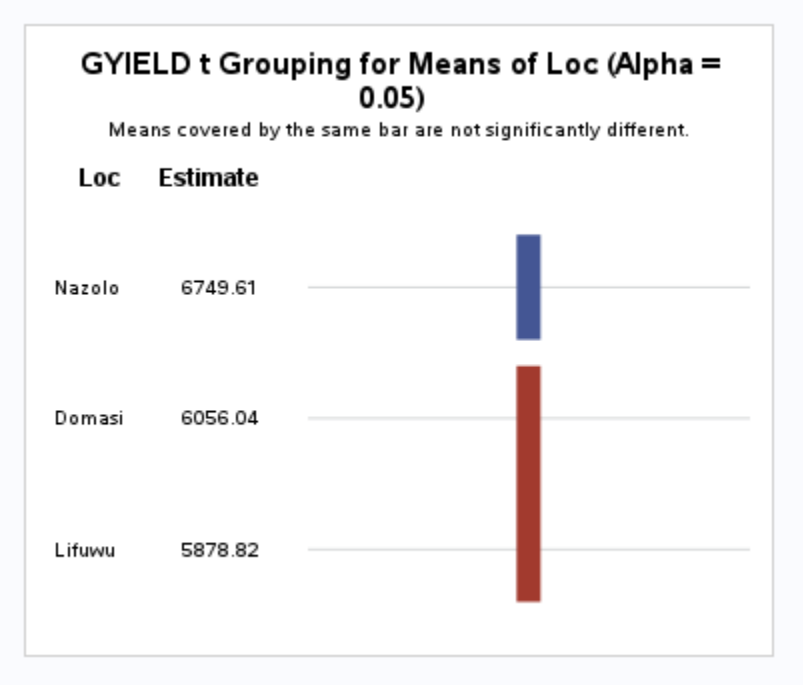

Figure 10. Mean comparison of grain yield from three locations in Malawi.

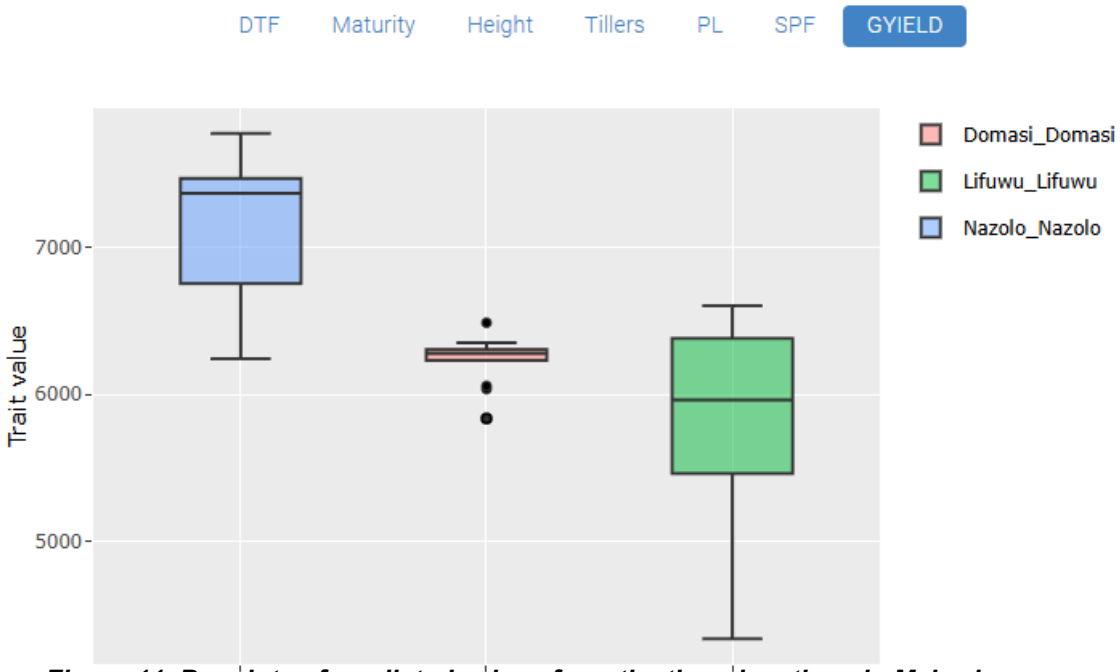

Figure 11. Boxplots of predicted values from the three locations in Malawi.

MILESTONES/ACHIEVEMENTS

- The HRDC Advisory Committee meeting was held in a face-to-face mode in Hyderabad
- HRDC organized a follow up on the Strategic Hybrid Rice Adoption workshop on April 5, 2024, in Hyderabad to understand the challenges in accelerating the wide scale adoption of the hybrid rice technology.
- The introgression of biotic stress tolerance genes for BPH, blast, and tungro into popular A/B pairs was completed, and seeds are multiplied for sharing.
- Testing of 29 hybrids in the One NARES network.
- Development of HRDC-NARES Green Revenue model for co-hybrid development. A model for the private sectors can also be developed for interested companies.

STATUS OF MEMBERSHIP

As of 31 December 2024, HRDC had a total of 89 members. Fifty-four members came from public organizations, seven in the Platinum-Green category. Twenty-eight are from private organizations, including two in the Platinum, 24 in Gold, and 2 in the Silver category (Figure 12).

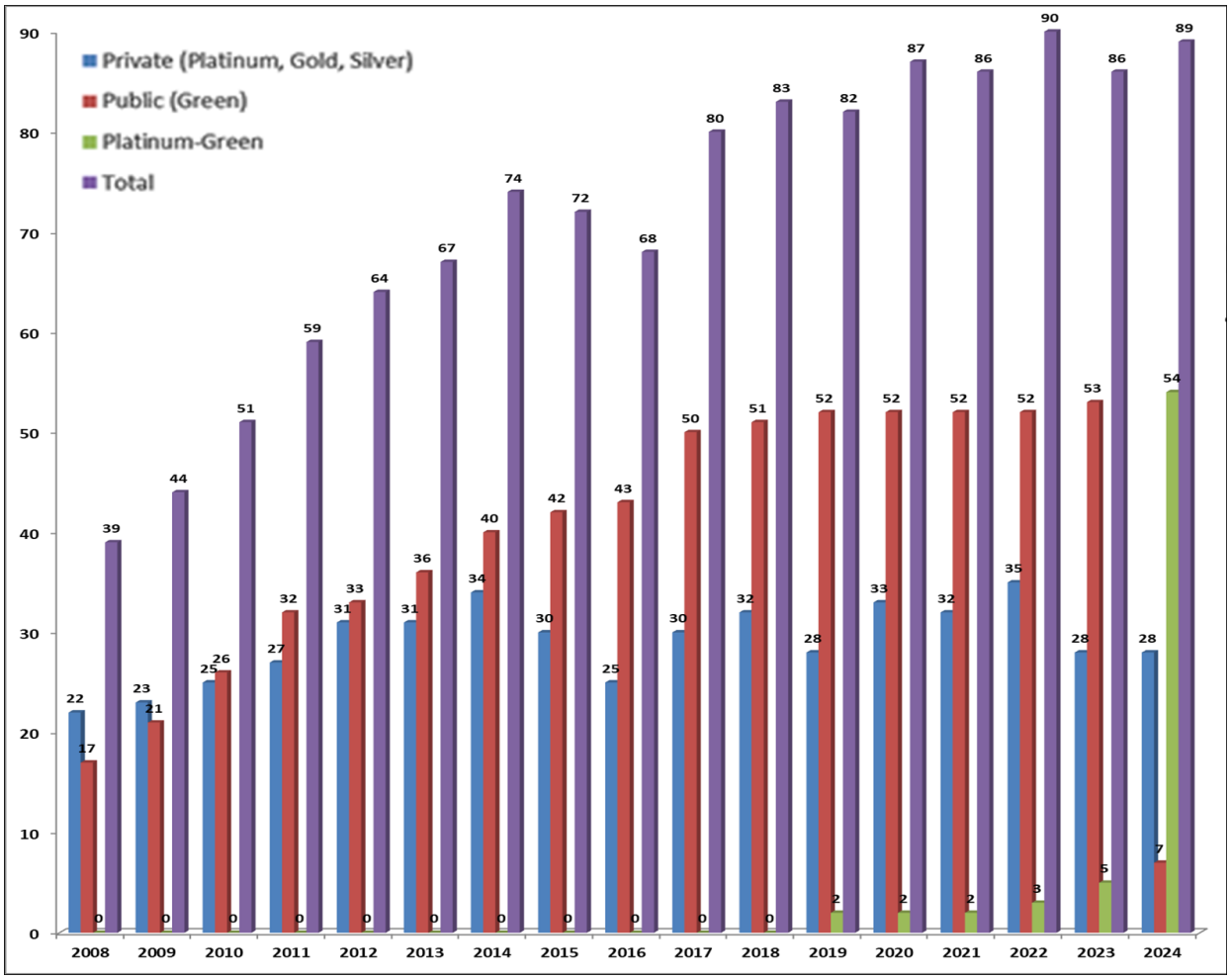

Figure 12. Growth of HRDC membership over the years.

FUTURE PLANS AND ACTIVITIES

- More advanced breeding materials facing the market will be shared to HRDC members especially emerging from IRRI's hybrid rice breeding program.

- The HRDC will attempt to provide a face-to-face training course on ***"Advances in Hybrid Rice Breeding."***

- All ongoing breeding activities will be advanced to the next generation and maintained (trait introgression, forward breeding, conventional breeding (B x B and R x R), along with well-defined heterotic pools to strengthen parental line breeding.

- IRRI will launch its Global AI-Hybrid Rice Platform (GAI-HRP) and all HRDC members are welcome to take the services to predict the best hybrid combinations.

- IRRI-HRDC projects have been successfully implemented to develop superior hybrid breeding products and also make them available to members.

- Socio-economic impact assessment of hybrid rice technology in India and the Philippines will be carried out in 2025-26.

- F_6-F_7 fixed materials generated from crosses from R x R and B x B based on heterotic pools and market segments will be shared with HRDC members along with trait-based marker data.

- We are planning to organize an IRRI-HRDC Advanced Hybrid Rice Trial of 15–20 promising IRRI hybrids over two seasons each year with HRDC members for evaluation against the best market checks and HRDC member hybrids in the target locations. The collective data would help us understand yield performance and market acceptability through HRDC members. The promising hybrids will be selected, and a hybrid seed reproducibility trial will be conducted at Hyderabad and IRRI headquarters to demonstrate this to members. This would promote licensing opportunities and help to provide quicker solutions to understand the parental materials required for different market segments. We highly encourage all HRDC members to undertake this trial in their respective target geographies and return the data for a combined yield trial analysis to identify the best hybrids for different market segments.

- We plan to submit 15–20 IRRI hybrids to the One IRRI-NARES breeding network management strategy (Figure 13). This system makes use of the hub and spokes model where regional breeding teams (NARES) are effectively engaged in South Asia (32 sites), Southeast Asia (5 sites), and Eastern and Southern Africa (6 sites). The IRRI-NARES breeding network will have joint network trialing, germplasm advancement and modernization, and capacity building with and among NARES partners through broader IRRI-NARES engagements.

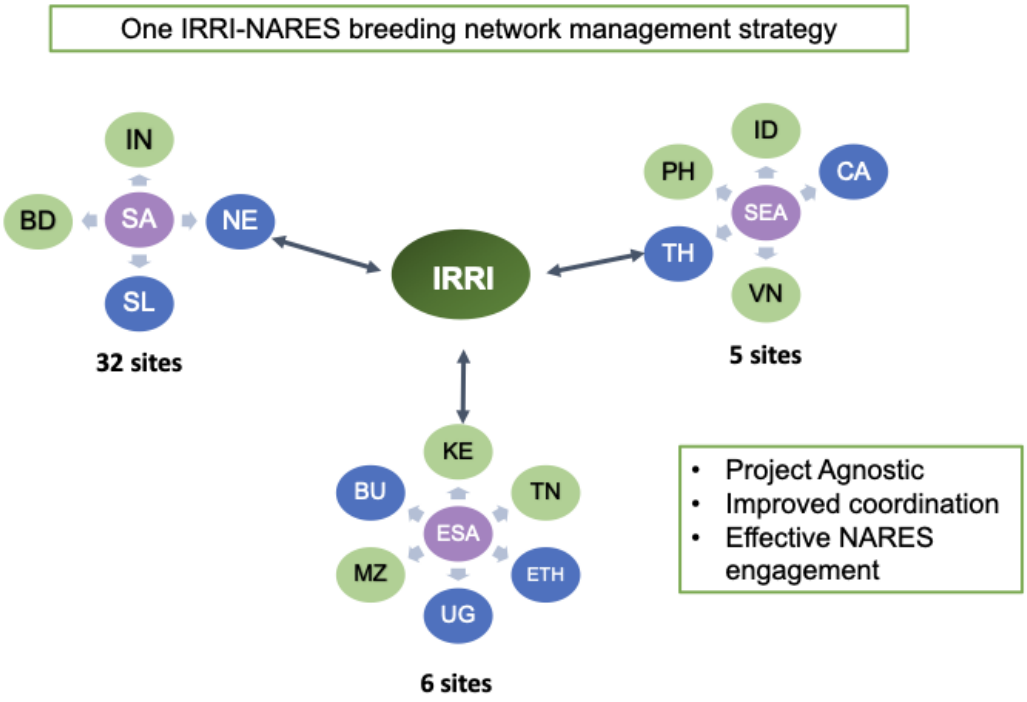

Figure 13. One NARES network testing of HRDC hybrids along with inbreds.

- Seeds of promising hybrid combinations will be shared with HRDC members for commercialization and licensing.
- HRDC members will be able to avail of a package for grain quality testing of elite lines and hybrids at concessional rates to match their needs at CERVA-ISARC, Varanasi, especially for South Asian regional needs; likewise, at IRRI HQ for Southeast Asian countries.
- HRDC members should contact the HRDC Secretariat for the non-exclusive licenses for shared CMS, maintainer, and restorer lines before commercializing the hybrid materials derived from them.

- HRDC seed production of promising hybrid combinations will be demonstrated each year, creating opportunities for licensing.
- Multiplication of parental lines is being done at the IRRI South Asia Hub to address the needs of HRDC members in India and prevent the seed logistics issues we are currently experiencing.
- All HRDC members are requested to share evaluation and trial data of HRDC materials each year without fail, as this will significantly enhance product development across different market segments.

Acknowledgments

We acknowledge the immense support from IRRI Technology Transfer led by Linga Gutha Reddy, Melannie Cabangbang, and Chrizzia Joce Veluz.

We also extend our gratitude to the IRRI South Asia Hub team led by Vikas Singh, with Challa Venkateshwarlu and Atul Singh, in establishing the HRDC seed multiplication and hybrid seed production, and for facilitating the seed distribution to the HRDC members in India.

Finally, the efforts and contributions of the hybrid rice breeding team: Angelito Galang, Carlos Casal, Jr., Adrian Roy Vijandre, Erik Jon De Asis, Madonna Angelita Dela Paz, Ma. Anna Lynn Sevilla, Christian John Robiso, Gelo Fontanilla, Michael Reyes, Pauline Trespalacio-Jasmin, Kristine Alexis Arellano, Lolita Mendoza, Carla Francesca Besa, Mayeth Magdasoc, Noel Llanza, Benvienido Bacani, Rommel Masa, Cenon Alvarez, Alexander Reyes, and Marino Reyes.

Annexure 1

Deliverables made available in 2024

(a) New parental lines and false smut materials

- Fifteen restorers with value-added genes, two restorers resistant to BPH, RTV, and blast, five false smut materials (4 resistant, 1 susceptible)

(b) New hybrids with characteristics

- Five hybrids with early to medium maturity

(c) New DNA marker

- Continuous validation and optimization of the existing *Rf4*, *WA-CMS* in the hybrid panel.
- Validation of some new traits in the hybrid panel, such as drought tolerance at reproductive stage, *HIS1 gene*, and grain quality traits

Annexure 2

Deliverables to be made available in 2025

(a) New parental lines and their main characteristics

- Fifteen restorer lines with value-added genes
- Two CMS pairs

(b) New hybrids with characteristics

- Five elite hybrids will be shared

(c) New DNA markers and marker platforms

- Continuous validation and optimization of the existing *Rf3*, *Rf4*, *WA-CMS*, and RFS in the hybrid panel.
- Additional target SNPs for important biotic traits (*Pi, TSV, Xa*) were also included in the hybrid panel.
- New SNP markers for gall midge, drought tolerance, salinity tolerance, and grain specific traits were added to the RiCA SNP panel.
- RBI will bring out 4K RiCA markers for its utilization by our HRDC members

(d) Training course/workshop

- We will provide an advanced hybrid rice breeding training course for 10 days
- On the job training for researchers and scientists on hybrid rice seed production (one month)

Appendix 1

2024 HRDC Annual Meeting

Appendix 2

Field Visit during the 2024 HRDC Annual Meeting

Appendix 3

Seed Producibility Trials visited by some HRDC Members at maturity

Advanta (Oct. 25, 2024)

Indo-American & Trimurti (Nov. 4, 2024)

Value Seeds (Nov. 5, 2024)

Appendix 4

List of hybrids nominated for One NARES Network

S. No.	Designation	DTF	DTM	Plant height (cm)	Tiller number	Amylose (%)	Milled rice (%)	Head rice (%)	Grain length	Grain shape
1	IR144672H	79	109	125	14					
2	IR144726H	78	108	116	19					
3	IR145504H	80	110	123	12	18.3	59.9	41.5	L	S
4	IR84714H	76	106	103	14	21.2	68.9	50.5	L	S
5	IR80637H	78	108	112	14	21.6	67.3	48.5	L	S
6	IR81949H	79	109	109	14	21.4	66.1	43.3	L	S
7	IR81955H	79	109	104	14	21.0	69.9	47.6	L	S
8	IR83199H	77	107	110	14	24.1	66.7	46.4	L	S
9	IR82363H	78	108	103	14	21.6	65.4	45.1	L	S
10	IR82372H	80	110	110	14	20.6	65.7	45.8	L	S
11	IR142461H	84	114	118	23	25.5	67.2	59.6	L	S
12	IR142464H	84	114	116	18	22.6	70.6	66.0	L	S
13	IR142481H	87	117	118	20	26.9	66.9	54.4	L	S
14	IR142467H	84	114	117	17	22.5	72.6	69.0	L	S
15	IR142484H	86	116	115	17	26.4	66.8	57.9	L	S
16	IR142493H	84	114	122	19	24.0	68.6	64.0	L	S
17	IR144693H	84	114	128	17	20.4	71.7	67.9	L	S
18	IR144714H	84	114	120	15	25.0	72.0	67.9	L	S
19	IR144651H	89	119	112	15					
20	IR144654H	87	117	120	14					
21	IR144698H	83	113	120	19	15.6	67.5	59.2	L	S
22	IR144719H	81	111	105	14					
23	IR144744H	86	116	120	19					
24	IR137227H									
25	IR145534H	85	115	114	12	24.3	68.4	51.8	L	S
26	IR145563H	81	111	122	20	16.5	64.2	50.3	L	S
27	IR145569H	84	114	117	14	23.3	68.2	58.5	L	S
28	IR139358H	90	120	120	15	22.3	72.0	61.3	L	S
29	IR134554H	84	114	120	13	20.1	70.9	60.1	L	S

HR2DC24

Hybrid Rice Development Consortium ANNUAL MEETING

Hybrid Rice Development Consortium
International Rice Research Institute
Los Baños, Philippines