SARC Cultivate

IRRI's hub for South-South Cooperation on Rice Research



SOUTH ASIA REGIONAL CENTR

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Dear <mark>reade</mark>r,

Greetings from the IRRI South Asia Regional Centre (ISARC), Varanasi!

It gives me great pleasure to share with you the fifth issue of the ISARC Newsletter - Cultivate. This newsletter will provide you with an overview of various rice innovations taking place at ISARC, Varanasi, and across the South Asian region.

On behalf of IRRI, I would like to thank our stakeholders in the South Asian region for their support in making the International Rice Congress (IRC) a huge success. IRC2023 was organized in the Philippines and had over 1950 registered participants, over 500 oral presentations (in sessions, as plenary, or as thematic keynotes), and around 350-400 poster presentations). This mega-success would have never been possible without the contributions of our stakeholders from around the globe. This congress provided a platform for the agri-food sector to convene, converse about the challenges and opportunities in the rice sector, and converge to find possible solutions to the challenges through collaborative efforts.

This December issue opens with some highlights of IRC covering events and sessions related to rice research and developments, specifically in the South Asia region. These include :

• Scientific breakthrough of IRRI in identifying genes responsible for low and ultra-low glycemic index in rice.

• Felicitation of **Dr. Himanshu Pathak**, Director General of the Indian Council of Agricultural Research for his leadership in advancing world-class science in rice-based food systems in India.

• A session on the transformation of rice value chains in Bangladesh and Nepal and the role ISARC could play in leveraging these activities in South Asia.

• A session covering IRRI-India's contribution to rice food and nutritional security which had a notable gathering of prominent scientists and officials of IRRI and Indian rice agencies.

It is a privilege for ISARC to act as a catalyst to bring partners together to ensure ground-breaking science, making our rice-based systems more sustainable, nutritious, and viable for the farmers. I am hopeful that this newsletter will provide a glimpse of our work and help us in enhancing our engagements with our stakeholders.

In the attached newsletter, you will find updates on the following.

• Entrepreneurs develop a roadmap for public and private companies to work together to strengthen the seed system in Assam: The International Rice Research Institute (IRRI) organized Strengthening Seed Ecosystem: Empowering Seed Entrepreneurs of Assam, a workshop to recognize the challenges faced by its seed entrepreneurs and explore possible solutions to strengthen the state's seed system.

• ISARC presents climate-smart initiatives for improving the livelihoods and climate resilience of farmers in South Asia: ISARC represented IRRI at the XXII Biennial National Symposium on Climate Smart Agronomy for Resilient Production Systems and Livelihood Security organized in Goa from November 22-24. • ISARC annual rice varietal cafeteria features 36 promising new varieties for Uttar Pradesh farmers: An Annual Rice Varietal Cafeteria Evaluation was arranged at ISARC to provide farmers and other stakeholders a platform to observe, assess, and select the best varieties that fit their needs. This crop cafeteria featured 36 new stress-tolerant varieties for the different rice-growing environments in Uttar Pradesh.

• ISARC hosts workshop to address the impacts of climate change on major cereal crops in Bihar and Uttar Pradesh: An international workshop, Prioritizing Agronomy in Changing Environment (PAiCE) was organized at ISARC on adaptation options addressing the adverse impacts of climate change on rice, wheat, and maize. The objectives of the workshop are to identify the potential adaptation options, evaluate them, and validate them for prioritization in Bihar and eastern Uttar Pradesh.

• IRRI and ICAR to further promote research and development on rice genetic resources: IRRI and the Indian Council of Agricultural Research - National Bureau of Plant Genetic Resources (ICAR-NBPGR) signed a Letter of Intent (LoI) to promote cooperation in research and development work related to rice genetic resources.

Along with these updates, the newsletter also covers various engagements and activities initiated by ISARC with stakeholders in the form of training, farmers' fairs, exhibitions, and visits. This newsletter also has a special section dedicated to published research papers and studies conducted by our scientists and experts. We also have announcements regarding our new initiatives and upcoming events featured in this newsletter.

I would be pleased to receive your feedback and interest in any of the featured innovations and initiatives. Please enjoy the read.

Sincerely,

Dr. Sudhanshu Singh Director, IRRI South Asia Regional Center

Highlights from International Rice Congress 2023

IRRI reveals scientific breakthrough for low and ultra-low glycemic index rice



Philippine President Ferdinand Marcos, Jr. and IRRI interim Director General Dr. Ajay Kohli at the opening ceremony of the International Rice Congress 2023

Manila, Philippines (October 16, 2023)

In an effort to help curb the rising cases of diabetes globally, scientists from the International Rice Research Institute (IRRI), a CGIAR Research Center, have identified the genes responsible for low and ultra-low glycemic index (GI) in rice. This new discovery will be able to convert popular rice varieties into low and ultra-low GI for refined white rice, through conventional breeding methods, keeping high-quality grain and without compromising yield.

The first batch of ultra-low GI rice samples, developed from the Samba Mahsuri x IR36ae, was formally presented to Philippine President Ferdinand Marcos, Jr. at the opening ceremony of the 6th International Rice Congress.

"Thank you for conducting the 6th International Rice Congress which I am sure will promote the development and use of more quality rice varieties and technologies such as the ultra low glycaemic index or ultra low GI rice," said Marcos. He added, "The discoveries in this congress will pave the way for greater strides in the rice industry in the Philippines and across the globe."

IRRI has previously identified two low GI Philippine varieties, IRRI 147 and IRRI 125, that were already released in the Philippines as salt-tolerant varieties. Based on clinical validation on human volunteers in a cohort study, IRRI 147 depicted a GI value of 55 and IRRI 125 had a GI value of 51.1.

Diabetes is growing globally at an epidemic rate. According to the International Diabetes Federation, there were 537 million people with diabetes in 2021 and this is expected to increase 47% by 2047. Many cultivated rice varieties have a GI ranging from 70 to 92, which is not considered healthy for people with diabetes.

IRRI classifies GI levels below 45 as Ultra-low, 46-55 as low GI, 56-69 as intermediate GI, and high GI at 70 and above. The newly discovered ultra-low GI line has a GI level of 44, with translucent backgrounds. In 2019, IRRI found highly significant marker-trait association markers for distinguishing intermediate versus high GI. The breakthrough comes in IRRI having now defined the genetics for low GI and Ultra-low GI and developed pre-breeding lines in a high-yielding background with low GI and ultra-low GI characteristic features.

"IRRI's latest discovery offers the opportunity to develop rice varieties with low GI, and for the first time ever, ultra-low GI levels, to meet the health needs and dietary preferences of consumers," said Dr. Nese Sreenivasulu, Head of IRRI's Consumerdriven Grain Quality and Nutrition Research Unit and the lead of this discovery, adding that in collaboration with relevant institutions in different countries, these lines can also be used as donors to transfer low and ultra low GI traits to popular rice varieties with different grain size and shape, as well as in different maturity backgrounds.

This scientific breakthrough comes from a wider South-South collaboration between IRRI scientists in the IRRI global headquarters hosted by the Philippines government and IRRI South Asia Regional Centre in Varanasi in India which was inaugurated by India's Prime Minister Narendra Modi with the aim to foster research partnerships across regions.



The Low GI has a much lower glucose peak and the Ultra-low GI lines release glucose at an extremely slow rate, compared to high-quality conventional rice which spikes sugar levels significantly within the same 40-minute window

"We are keen on supporting the continued research for this milestone discovery. We are already discussing ways on how PhilRice can use this breakthrough on low GI rice toward incorporating this in Philippine varieties," Dr. Leo Sebastian, Undersecretary for Rice Industry Development of the Department of Agriculture, said.

"These research breakthroughs possess much-needed health benefits and tremendous market potential. We look to partnering with as many national systems as possible to help fast track the release of low and especially the ultra-low GI rice varieties," said IRRI Interim Director General Dr. Ajay Kohli, adding that the ultra low GI variety will be market-ready within two years through a collaboration between IRRI and PhilRice.



Delegates at the launch of ultra-low GI rice samples at IRC

IRRI honors Dr. Himanshu Pathak for his contributions to India's rice sector at IRC 2023



(from left to right) IRRI DDG-SEI Joanna Kane Potaka, ICAR DG Dr. Himanshu Pathak, IRRI interim DG Dr. Ajay Kohli, IRRI-India Research Coordinator Dr. Nese Sreenivasulu, ISARC Director Dr. Sudhanshu Singh

Manila, Philippines (October 18, 2023)

Dr. Himanshu Pathak, Director General of the Indian Council of Agriculture Research (ICAR), was given an Award of Appreciation by the International Rice Research Institute (IRRI) for his leadership in advancing world-class science in rice-based food systems in India and around the world and his long-standing partnership with IRRI.

Dr. Pathak is the Secretary of the Department of Agricultural Research and Education (DARE) and serves as the Director General of the Indian Council of Agricultural Research (ICAR) in New Delhi. In his role, Dr. Pathak provides visionary leadership to one of the world's largest agricultural research and development organizations. He is an alumnus of IRRI. At IRRI, he served as Co-Facilitator of the Rice-Wheat Consortium of the Indo-Gangetic Plains. Before becoming DG of ICAR, he served ICAR in different capacities such as Director of ICAR-National Rice Research Institute in Odisha and the Director of ICAR-National Institute of Abiotic Stress Management in Maharashtra, India. "With over three decades of expertise in agricultural research, education, and extension, Dr. Pathak is a true luminary in the field," said Dr. Ajay Kohli, interim DG of IRRI. "His profound knowledge in research on rice-based systems and climate change positions him as a key asset, where his insights will be instrumental in shaping strategic recommendations and implementing resilient rice systems in the face of climate challenges."

The award was given during the IRRI-India's contribution to rice food and nutritional security, a special session at the 6th International Rice Congress that showcased the role and achievements of the country's rice agencies and programs separately and in collaboration with IRRI.

Also at the award presentation were IRRI officials Ms. Joanna Kane-Potaka, Deputy Director General for Strategy, Engagement, and Impact; Dr. Sudhanshu Singh, Director of the IRRI South Asia Regional Centre (ISARC), and Dr. Nese Sreenivasulu, IRRI-India research coordinator and leader of the Consumer-Driven Grain Quality and Nutrition Unit.

Transformation of rice value chains in Bangladesh and Nepal: Status, Challenges, and Vision



Manila, Philippines (October 18, 2023)

Bangladesh and Nepal are two important rice economies of South Asia with large rice consuming populations. Rice productivity in these countries often goes beyond food security. It is at the core of these countries' social and economic stability and environmental sustainability. However there are some common and stark differences in rice production challenges between the two countries. In the past two decades, Bangladesh turned from rice deficit to surplus while Nepal turned from rice surplus to deficit. Rice scientists and policymakers from Bangladesh, Nepal, and South Asia came together at the 6th International Rice Congress in Manila to discuss these as well as other challenges, and their future visions for the Bangladesh and Nepal rice sectors.

Dr. Jongshoo Shin, Regional Director for Asia at the International Rice Research Institute, opened the session on the Transformation of rice value chains in Bangladesh and Nepal: Status, challenges, and vision. Dr. Shin invited panelists to share a bigger picture of Bangladesh and Nepal and to help analyze factors that impact or could contribute more to these countries' rice productivity such as post-harvest losses, market linkages, and access to finance. Panelists were also asked to put forward a viable direction and set of solutions to the challenges both countries are facing in this area.

The first presentation of the session was on the transformation of the rice value chains in Bangladesh by Dr. Md Shahjahan Kabir, Director General,

Bangladesh Rice Research Institute (BRRI), where he spoke about the history of rice farming in Bangladesh, how the country moved from being a food-deficit country to being a food surplus nation and the drivers which led to this success.

"Significant transformations have been brought with the introduction of the new and productive boro rice season, the development and adoption of more productive high yielding varieties, increasing cropping intensities and diversified cropping, and introduction and adoption of stress tolerant varieties of rice," Dr. Kabir said. He also commended the visionary leadership of Honorable Prime Minister of Bangladesh, Sheikh Hasina, on agricultural development and the government's strong support in terms of policy and funding which have significantly helped farmers and ushered in a more vibrant agricultural community. He also pointed out the role which BRRI and the Bangladesh Institute of Nuclear Agriculture (BINA) have played in strengthening the country's rice sector while promoting agricultural sustainability through innovation and inclusion.

The second presentation was on the transformation of rice value chains in Nepal by Dr. Dhruba Raj Bhattarai, Executive Director of the Nepal Agriculture Research Council (NARC). Dr. Bhattarai highlighted that in the past few years, Nepal turned from rice surplus to experiencing a deficit leading to large rice imports which became a big concern for national food security. Factors like limited availability of improved varieties, limited irrigation facilities, subsistence farming with limited technology-intensive rice-farming, limited use of modern inputs, climate change and policy challenges have resulted in slow growth in rice production and large yield gaps over the past few years.

"Some of the biggest challenges in rice farming in Nepal have been due to the resource constraint, inadequate access to suitable high yielding variety seeds in sufficient quantities as well as diverse environments and terrain of Nepal," shared Dr. Bhattarai. He also highlighted limited access to markets and market infrastructure and the open border and competition with India rice varieties. He hopes that Nepal would be able to turn around rice production in the next three years with the promotion of climate-resilient rice varieties and sustainable farming practices, strengthening of the market infrastructure, capacity building in advanced science and technologies, and recruitment of extension workers with updated knowledge and skills.



Dr. Sudhanshu Singh, Director, IRRI South Asia Regional Centre (ISARC), highlighted the cutting-edge facilities, laboratories, and scientific expertise at the centre in Varanasi, India and how both Bangladesh and Nepal can leverage this toward achieving their goal of improving and increasing rice productivity in their countries in the coming years.

A panel discussion during the session also took place with participation of distinguished policymakers and rice scientists from Bangladesh, Nepal and South Asia. The panel included Dr. Rabindra Sri Barua, Additional Secretary, Ministry of Agriculture, Government of Bangladesh; Dr. Abdullah Sazzad, Chairman, Bangladesh Agricultural Development Corporation; Dr. Md. Shahjahan Kabir, Director General, BRRI; Dr. Shamsun Nahar Begam, Head of Plant Breeding Division, BINA; Dr. Dhruba Raj Bhattarai, Executive Director, NARC; Dr. Hari Bahadur KC, Director General, Department of Agriculture, Ministry of Agriculture and Livestock Development, Nepal; and Dr. Uma Shankar Singh, Asia and Africa Advisor for Research and Partnership, IRRI. The discussions on Bangladesh centered on the priorities of the government in increasing rice productivity. Bangladesh is one of the most vulnerable countries to climate change challenges which have been on the rise. Bangladesh is working to increase productivity, profitability, resilience, and sustainability of its rice value chains.

The urgently needed solutions raised for Bangladesh were the development of high-yielding and stress tolerant varieties of rice, strengthening of the seed system, moving from food security to nutrition security through biofortification, and the potential contribution of genome editing and speed breeding, among others.

Nepal too hopes that agriculture-friendly government policy, subsidies on seeds, fertilizers, inputs, and improved access to more appropriate machinery would encourage farmers to move beyond subsistence farming. Promotion of spring rice is another option that could prove to be beneficial for Nepal. Public-private partnership with the government of Bangladesh and ISARC would go a long way in strengthening rice farming in Nepal.

Dr. Uma Shankar Singh highlighted how both countries could further benefit from Seeds without Borders, IRRI's seed sharing agreement for regional collaboration, which would speed up the distribution of modern rice varieties in both Bangladesh and Nepal.

The event provided opportunities to share knowledge on successes, challenges, and future visions to transform the rice value chains in Bangladesh and Nepal, and how two countries can benefit from IRRI's science, technology, and innovation.

Achievements of Indian rice research and IRRI partnership showcased at IRC 2023



(in clockwise order) ICAR DG Dr. Himanshu Pathak, Ministry of Agriculture and Farmer's Welfare Joint Secretary Mr. Pankaj Yadav, IRRI interim DG Dr. Ajay Kohli, and IRRI Asia and Africa advisor for research and partnership Dr. Uma Shankar Singh at the session.

Manila, Philippines (October 18, 2023)

The International Rice Research Institute (IRRI) showcased the many accomplishments of Indian scientists and agencies in advancing rice science and rice sector development during a special session in the recent 6th International Rice Congress (IRC).

Entitled IRRI-India's contribution to rice food and nutritional security, the session was a noteworthy gathering of prominent scientists and officials of IRRI and Indian rice agencies, who talked about the history, legacy, and achievements of the IRRI-India partnership, and how it has contributed to India's leading position in the global rice sector.



J.K. Ladha, an IRRI alumni and currently adjunct professor of Plant Science at the University of California Davis, looked back at the inception of the IRRI-ICAR research cooperation in 1967, and remarked on how this evolved into a multi-faceted partnership across multiple fields, including breeding, capacity building, genetics, grain quality, and social and gender studies, among many others.

"IRRI's collaboration with India is the largest and is very active and vibrant," Dr. Ladha said. "India has been a key participant in many of IRRI's programs, including consortia and networks, and plays a collaborative role in priority setting, strategy planning, scientific advisory, and implementation."

Equally important presentations from other foremost Indian agricultural experts also highlighted urgent needs and priority research areas for the country.



Raman Sundaram, Director of ICAR-Indian Institute of Rice Research, talked about how the India Coordinated Research Project on Rice (AICRPR) plays a significant role in boosting India's rice sector.

Established in 1965, AICRPR (formerly the All India Coordinated Rice Improvement Project) is supported by the largest research network devoted to a single crop. It has over 45 funded centres, 100 voluntary centers, and 30 private organizations across the country. To date, the project has released over 1,500 rice varieties and hybrids in India, including several high-yielding mega-varieties, stress-resistant varieties, and zinc- and protein-biofortified varieties.

"The project successfully consolidates and accelerates India's research and development into improved rice varieties, benefitting food and nutrition security," said Dr. Sundaram. "Current and future initiatives for AICRPR include market-oriented breeding, developing varieties and hybrids suited for direct seeding, and integrating varietal improvement with crop production programs."



Amaresh Kumar Nayak, Director of ICAR-National Rice Research Institute, discussed how agronomic interventions and direct-seeded rice (DSR) can help sustain productivity in intensive rice cropping systems.

The DSR system is practiced in approximately 4.5 million hectares across India. Trials in land preparation, seed selection and treatment, and mechanized seed sowing demonstrated good results for DSR. Herbicide-tolerant rice varieties and integrated nutrient management are being tested to control weeds and enhance nutrient-use efficiency. Mechanization in seed establishment and drone herbicide spraying are also being studied. "Tested against traditional transplanted rice, modern and optimized direct seeding offers greater water and energy productivity, with methane emissions reduced by up to 30%," said Dr. Nayak. "The challenges we need to overcome for the greater adoption of DSR include the development of suitable varieties and herbicides, effective weed and pest management, and lack of awareness of DSR cultivation methods."

With the strong collaboration of ISARC and IRRI, the breakthrough of ultra-low glycaemic index rice varieties with a GI value below 45 has been developed. A first set was formally presented to Philippine President Ferdinand Marcos, Jr. during the IRC 2023 opening ceremony. Mr Pankaj Yadav, Joint Secretary of the Ministry of Agriculture and Farmer's Welfare and also present in the event lauded IRRI for this breakthrough and expressed their full support of this undertaking as it gets rolled out in India. "On behalf of the Ministry of Agriculture and Farmer's Welfare, I congratulate ISARC and IRRI for this significant achievement," said Mr. Yadav.



Dr. Sudhanshu, Secretary of the Agricultural & Processed Food Products Export Development Authority (APEDA), presented his agency's role in promoting Indian agri-exports, particularly rice and rice products. Cereals make up 51% of APEDA's exports, with rice categorized as Basmati and non-Basmati. India is the leading exporter of Basmati rice to the global market with over 4 million tons exported in 2022.

APEDA leads efforts to monitor the registration and trademarks of Basmati rice to protect the variety in the market. APEDA has also collaborated with IRRI on grain and nutrition profiling of non-Basmati rice, as well as the development of value-added rice-based food products such as ice cream, pasta, and biscuits. "While not a research institute, APEDA is a partner of ICAR and IRRI in the rice sector," said Dr. Sudhanshu.

"We work towards marketing and promoting India's rice varieties and rice-based products in global trade, contributing to India's position as a top player in rice," said Dr. Sudhanshu who also echoed Mr. Yadav's support of IRRI's efforts on low and ultra low GI rice for India. "We will aim for creating stronger private-sector linkages which will promise a wave of exciting innovations in the commercialization of quality rice products in the region."

Dr. Sudhanshu Singh, Director of the IRRI South Asia Regional Centre (ISARC), highlighted the triple burden of malnutrition and micronutrient deficiency as one of the pressing challenges being tackled by ISARC through its various units.

Aside from its technical capacity, ISARC's key strength lies in its ability to facilitate and contribute to bilateral and multilateral projects in India and around the world. ISARC is currently part of 12 international projects and 19 bilateral projects with Indian agencies. Opportunities for collaboration include modernization of breeding systems, intensification and diversification of rice-based cropping systems, and rice value chain improvement, among others.

"ISARC's research plays a key role in the region for feeding a growing population, providing a healthy diet, protecting the environment, and tackling the climate crisis," said Dr. Singh. "Moreover, by coordinating with national and international stakeholders from the public and private sector in scaling research and innovations, we enhance South-South cooperation for South Asia and Africa."

Uma Shankar Singh, IRRI Asia and Africa advisor for Research and Partnerships, presented an update on Seeds Without Borders, a groundbreaking regional seed policy agreement that began in 2013 and now includes Bangladesh, Bhutan, Cambodia, Fiji, India, Nepal, Philippines, Sri Lanka, and Vietnam.

The latest agreement, signed in November 2022 in Thimphu, Bhutan, significantly expands the scope of the agreement, to include roots and tubers and fruit crops, varieties developed by the private sector, and the development of a database of different crops for sharing among the group. Examples of this cooperation and sharing include India requesting 10 varieties from Bangladesh and two from Nepal, Nepal releasing 3 rice varieties from India, and Fiji requesting 1 sorghum, 1 pearl millet, and 2 rice varieties from India.

"All signatory countries will establish nodal cells for greater coordination," said Dr. Singh. "Expanding the agreement will contribute to the enhancement of seed systems, varietal improvement, and capacity building to support food and nutrition security in member countries. Looking ahead, we hope to include more countries, especially in Africa, promoting greater seed sharing and South-South cooperation."



6TH INTERNATIONAL RICE CONGRESS

"Thank you for making #IRC2023 a grand success!"

FEATURES

Winner of the prestigious Norman Borlaug Field Award 2023, Dr. Swati Nayak's exclusive interview with the Assam Tribune

'Quality seed alone can raise crop productivity'

Face to Face Prasanta J Baruah

Dr Swati Nayak is an agriculture scientist and seed system expert with International Rice Research Institute (IRRI). She is the recipient of prestigious Norman Borlaug Field Award 2023, given by World Food Prize Foundation.

Congratulations. What is the significance of the Norman Borlaug Field Award for you?

Being a woman agriculture field scientist who has been working for decades in ensuring that technology is transferred to smallholders, and innovations are brought out of lab and research stations to the doorsteps of last-mile farmers: this award is a testimony! This re-establishes and brings the focus back to the need and criticality of intensive agriculture extension and delivery models, and better investment on the same for real and on-the-ground impact of science.

How did you try to close the gap between scientific knowledge and its practical applications for farmers?

I focused on institution building as well as capacity development of key institutions, actors and scaling agents in germplasm/seed delivery systems of South Asia, and beyond. It was carried through an intensive public-privatecommunity partnership, engaging diverse stakeholders from national systems starting from breeders to extension officials, community institutions and also market actors like dealers, millers and several private institutions.

How did you go about in leading a dedicated initiative for women farmers approved by the Indian Cabinet?

In my very early career days, I got an amazing opportunity to work for women farmers through a dedicated initiative called Mahila Kisan Shasaktikaran Pariyojana. That gave me great exposure to nuances of different structural, operational and policy level challenges, opportunities in mainstreaming women in agriculture. This also helped me in forming a knowledge repository of comprehensive best practices in our country that has been under way to engage and empower women in agriculture. While no single approach could be perfect and it needs contextual improvisation, the experience made me target better on women's participation, income, decisionmaking and visibility in my research endeavours.



You have successfully disseminated more than 20 promising climate-resilient and bio-fortified rice varieties. How did you go about it?

We started with varietal intelligence engaging intensively with national breeding programmes and tracking new germplasms. We carried comprehensive, statistically rigorous on-farm testing of many new germplasms. We always compared these against the most popular and highly demanded existing farmer varieties to provide a value proposition for the farmers and other users. The large-scale adaptation testing (across key ecological hotspots) gave reliable evidence. This paved the way for successful positioning and scaling of many critical new varieties which are steadily expanding in seed chain of targeted areas through multiple innovative platforms and models around demand, and awareness generation.

Which are the climateresilient rice varieties promoted in Assam?

In Assam, multiple Sub1 varieties including Swarna-Sub 1, Ranjit-Sub 1, Bahadur-Sub 1, and BINA Dhan 11 have performed remarkably well. IRRI, with its implementing partners AAU, DOA, Govt of Assam under the World Bankfunded APART project has created a significant momentum. The Sub1 varieties have resilience against submergence up to 14 days. A yield advantage of 0.7 t/ha has been estimated against farmer varieties. The drought-tolerant varieties like DRR Dhan 44 have also been performing well. These varieties are acting as in-kind insurance mechanisms for farmers against crop loss. In addition, low-input responsive varieties, namely BINA Dhan 17 (now very popular in Boro season) have been doing increasingly well.

What is the impact of quality seeds in increasing productivity of rice cultivation?

Quality seeds alone can contribute 15 per cent increase in crop productivity. It is the genetic repository of a variety and carrier of embedded genetic gain through various superior traits like yield, aroma, grain quality, biotic and abiotic stress resilience. This is also the most low-cost technological innovation a smallholder farmer can adopt in a sustainable manner to ensure higher productivity, climate resilience, nutrition and income by leveraging key value-added traits in targeted/specific variies.

What are the challenges in paddy seed sector of Assam?

Some key challenges in Assam paddy seed sector are lack of enough localized Statebased seed enterprises/growers and high dependency on the adjoining State of West Bengal. The local seed dealership network is relatively less prevalent unlike in other States. This creates some extra and additional pressure on government programmes and distribution systems amidst limited resources, infrastructure and manpower. This calls for a concrete public-private partnership roadmap and creation of alternative channels and enterprises. The area and ecology in Assam, however, remain conducive for seed production as the State is known as a rice biodiversity hotspot.

How is IRRI helping Govt of Assam in providing quality paddy seeds in the State?

IRRI, in collaboration with Assam Agricultural University, and Department of Agriculture has been working on a twopronged strategy for seed system development of selected varieties. They have been working towards ensuring enough early generation seeds (breeder seed and foundation seed) produced at different locations under careful supervision of breeders and institutional multipliers and then the quality/certified/commercial seed is further increased through rigorous partnership with publicprivate community multipliers. Alternative seed enterprises led by farmer institutions are also mainstreamed to add to the mix.

How can a farmer producer company play a role in strengthening the seed system in Assam?

Farmer producer companies can form an alternate pillar to strengthen localized and faster seed provisioning in Assam. As the demand for seeds remains high in Assam, they do have business potential. However, they would certainly need rigorous capacity development, policy support and handholding in initial years to develop their business skill, negotiation power, market intelligence system to position themselves well in the seed market space.

What are the prospects for seed entrepreneurs in Assam?

Amidst low seed replacement rates, continued demand for quality seed, and lack of enough State-based enterprises, there is potential for seed business for individual entrepreneurs. They could play a role either across full-fledged seed production, processing, marketing engagements or in any or either stages while being linked up with larger seed companies. Amidst the absence of strong dealership network, many can flourish in those roles as well.

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illuminata podcast

Sugandha Munshi

The importance of Women Farmers Unheard Being Heard Dr Sugandha Munshi Senior Associate Scientist and Lead specialist, Sustainable Impact Department was interviewed by Illuminata which highlights the importance of women in agriculture and STEM at global level. This particular podcast highlights the achievements and work of extraordinary women

working in science and hosts women to discuss their path in STEM and share advice to inspire the next generation of women in agriculture.

Scan the QR Code to listen to this podcast



WORKSHOPS & EVENTS

Entrepreneurs develop a roadmap for public and private companies to work together to strengthen the seed system in Assam



Dr. Swati Nayak addressed the inaugural session of the workshop.

Guwahati, India, (November 20, 2023)

The International Rice Research Institute (IRRI) organized Strengthening Seed Ecosystem: Empowering Seed Entrepreneurs of Assam, a workshop to recognize the challenges faced by its seed entrepreneurs and explore possible solutions to strengthen the state's seed system.

"Rice is the mainstay of agriculture in Assam," said Mowsam Hazarika, Director of the Assam Seed and Organic Seed Certification Agency. "Rice is grown in 2.4 million hectares, out of the 2.6 million hectares under food grains in the state, producing 5.2 million tons of grain."

In 2020 – 2022, rice production contributed 5.5 million tons or 95% of the total food grains in Assam. However, the average productivity of rice in the state is only 2.2 tons/hectare, which is lower than the national average of 2.7 t/ha, according to Mr. Hazarika.

"Unavailability and non-accessibility to quality seed is a persisting problem in the region," he added. "Most of the public- and private-sector seed companies have little or no presence in Assam."

Only a few individual seed entrepreneurs and private seed companies are actively engaged in paddy seed production in Assam that contribute to the seed system. In 2023-2024, 19% of the total seed production area is registered to 33 farmer-producer companies and Assam Seed Corporation Ltd. The remaining areas are registered to individual seed entrepreneurs and private seed farms.

IRRI South Asia Seed Systems and Product Management Lead and 2023 Borlaug Field Awardee Dr. Swati Nayak cited examples of different successful models of seed business across different countries. Dr. Nayak encouraged seed entrepreneurs to map the demand and supply of different paddy varieties in Assam.

During the activity, participants developed a roadmap where public and private seed companies can work together to address the challenges of the seed business in Assam through a better convergence platform.



ISARC presents climate-smart initiatives for improving the livelihoods and climate resilience of farmers in South Asia



Goa, India, (November 22-24, 2023)

Top officials of the International Rice Research Institute South Asia Regional Centre (ISARC) represented IRRI at the XXII Biennial National Symposium on Climate Smart Agronomy for Resilient Production Systems and Livelihood Security.

ISARC Director Sudhanshu Singh called attention to the major challenges confronting rice production on account of extreme climatic variabilities.

"Challenges such as climate change, drought, submergence, salinity, and conventional crop establishment methods with sub-optimal management practices affect the productivity of rice crops and succeeding rabi crops rice-based system," Dr. Singh said. "Rainfed ecologies, particularly in South and Southeast Asia, face significant vulnerabilities that adversely impact agri-food production systems and farmers' livelihoods."

He highlighted how IRRI is making agronomic innovations and interventions holistically to enhance smallholder livelihoods and climate resilience in stress-prone environments.

"Scientists at IRRI are constantly working on developing advanced rice breeding lines and tailored agronomic practices to adapt to climate change," said Dr. Singh. "Based in Varanasi, ISARC has the advanced SpeedBreed Facility for faster development of climate-resilient varieties."

Panneerselvam Peramaiyan, head of the Centre of Excellence in Sustainable Agriculture at ISARC, emphasized the contribution of mechanization to

higher productivity, profitability, and resilience of rice-based systems through timely planting of rice and succeeding crops. He also stressed that mechanization and remote sensing-based suitability mapping brings more rice-fallow areas under pulse cultivation in the fragile ecologies of eastern India.



Dr. Panneerselvam Peramaiyan delivering his presentation at the event

"Mechanization also addresses the issues of labor and water shortage, rising production costs, and methane emissions," added Dr. Peramaiyan, who was honored with the Best Oral Presentation Award at the symposium for his talk titled Mechanized crop establishment methods for improving rice-based systems productivity in Eastern India.

The symposium was organized by the Indian Society of Agronomy in collaboration with the Indian Council of Agricultural Research (ICAR) in New Delhi, and ICAR-Central Coastal Agricultural Research Institute in Goa.

ISARC annual rice varietal cafeteria features 36 promising new varieties for Uttar Pradesh farmers



Farmers participating in cafeteria evaluation at ISARC, Varanasi.

Varanasi, India, (November 23, 2023)

The International Rice Research Institute (IRRI) South Asia Regional Centre (ISARC) hosted the Annual Rice Varietal Cafeteria Evaluation to provide farmers and other stakeholders a platform to observe, assess, and select the best varieties that fit their needs.

The crop cafeteria featured 36 new stress-tolerant varieties for the different rice-growing environments in Uttar Pradesh. It is organized under the guidance of ISARC Director, Sudhanshu Singh and IRRI Seed System and Product Management South Asia Lead and 2023 Norman Borlaug Field Scientist Award recipient, Swati Nayak.

The rice varietal cafeteria showcased the flood-tolerant Swarna-Sub1, Samba Mahsuri-Sub1, and BINA 11; drought-tolerant BINA dhan-17, CG Barani-2, Tripura hakachuk 2, and BRRI 75; varieties tolerant to multiple stresses such DRR dhan-50 and CR dhan-801. The high-yielding Sabour Sampanna, Sabour Heera, MTU 1156, and NLR 4001, and popular local varieties such as Sarju 52 and Chintu were also displayed. To address hidden hunger, the event introduced biofortified high-zinc varieties, namely DRR 48, BRRI 84, and BRRI 100.

The event also included discussions on seed entrepreneurship, early-generation seed production, and community seed production with farmer-producer organizations and companies. "Such events are sure to play a crucial role in advancing sustainable agriculture for farmers in Uttar Pradesh," Dr. Nayak said. "The varietal cafeteria model serves as a platform for participatory selection that incorporates inputs from stakeholders in the rice production chain. This event at ISARC is part of broader efforts across South Asia to raise awareness among value chain actors, ensuring the integration of new rice varieties into the production chain."

In recent years, the Seed System Unit of ISARC has acted as the focal point for disseminating multiple rice varieties across various districts in Uttar Pradesh through extensive on-farm trials, cluster demonstrations, minikit distributions, and community-based seed production system.

Varieties such as MTU1156, Swarna Sammriddhi, CG Devbhog, Telangana Sona, and many others are being made available to farmers through the unit's varietal dissemination models comprising of early-generation seed production, quality seed production training, and collaborations with public and private stakeholders.

"Collaborative approaches between farmer clusters, IRRI, and our organization are required for establishing seed entrepreneurship," said Dr. Jitendra Tomar, managing director of Uttar Pradesh Beej Vikas Nigam. "This will not only ensure better income but will ensure quick dissemination of improved varieties of rice across the state."

IRRI has organized similar varietal cafeteria events in Telangana, West Bengal, Chhattisgarh, Bihar, Odisha, and Jharkhand in India and Bangladesh and Nepal. These activities help farmers identify improved rice varieties suitable for different agro-climatic conditions. The activities also promote knowledge and awareness of modern agricultural practices and the importance of quality seeds among farmers, strengthen collaboration among stakeholders for improved coordination in the seed value chain, and create scope for scaling of varieties. ISARC hosts workshop to address impacts of climate change on major cereal crops in Bihar and Uttar Pradesh

Varanasi, India, (November 26, 2023)

The International Rice Research Institute (IRRI) South Asia Regional Centre (ISARC) in Varanasi hosted Prioritizing Agronomy in Changing Environment (PAiCE), an international workshop on adaptation options addressing the adverse impacts of climate change on rice, wheat, and maize. The objectives of the workshop are to identify the potential adaptation options, evaluate them, and validate them for prioritization in Bihar and eastern Uttar Pradesh.

"PAiCE is an interactive tool developed to aid in the prioritization process of mitigating climatic hazards and the identification of adaptation options," said ISARC Director Sudhanshu Singh. "It deals with the system characterization of key crops based on their area and economic value of production and the identification and prioritization of major climatic challenges and hazards for each crop and season.



The workshop was jointly organized by the Cereal Systems Initiative for South Asia (CSISA), a regional program of Excellence in Agronomy (EiA), Transforming Agrifood Systems in South Asia (TAFSSA), and the Indian Council of Agricultural Research-Central Research Institute for Dryland Agriculture (ICAR-CRIDA), Hyderabad.

Addressing the event, ICAR-CRIDA Director Dr. V. K. Singh appreciated the world-class and technologically advanced scientific facilities available at ISARC that could help the stakeholders associated with IRRI in accelerating and scaling their knowledge and services. "We are highly thankful to ISARC for hosting this workshop and providing an excellent platform for the distinguished agronomy experts from different agencies across South Asia to interact among themselves and discuss the third module of the PAiCE tool. I am hopeful that at the end of the workshop, we will have an efficient and validated module for the eastern IGP (Bihar and UP)", Dr. Singh remarked.

EiA aims to increase the productivity and quality per unit of input (agronomic gain) of millions of smallholder farming households in prioritized farming systems by 2030. The initiative emphasizes women and young farmers, showing a measurable impact on food and nutrition security, income, resource use, soil health, climate resilience, and climate change mitigation.

"As part of its mandate, EiA intends to undertake stakeholder consultations/workshops to understand the priority areas of interventions to address production constraints and emerging challenges confronting smallholder farmers within Bihar and the eastern Indo-Gangetic Plain," said Virender Kumar, research leader of the Climate-adaptive Agronomy & Mechanization Unit at IRRI.

"The prioritization is targeted to consider the climate adaptation and mitigation options based on the potential hazards, as well as sustainable intensification practices relevant to different crops and cropping systems in the region," Dr. Kumar said. "In this context, EiA-CSISA and ICAR-CRIDA started building a participatory approach in co-designing and developing implementation plans in Bihar and eastern Uttar Pradesh".

Peter Crafurd, CIMMYT country representative for Nepal, emphasized the importance of PAiCE. He added that disaggregating R&D, scaling, and risk transfer priorities will help make the most of public and private sector investment and that the clearly articulated priorities for specific production ecology contexts will empower rapid adaptation transitions.

IRRI and ICAR to further promote research and development on rice genetic resources



Dr. Sudhanshu Singh, director of ISARC, and Dr. Gyanendra Pratap Singh, director of ICAR - NBPGR, at the IRRI India Office in New Delhi.

New Delhi, India, (December 06, 2023)

The International Rice Research Institute(IRRI) and the Indian Council of Agricultural Research -National Bureau of Plant Genetic Resources (ICAR-NBPGR) signed a Letter of Intent (LoI) to promote cooperation in research and development work related to rice genetic resources.

The LoI was signed by Sudhanshu Singh, Director of IRRI South Asia Regional Centre (ISARC), and Gyanendra Pratap Singh, Director of ICAR-NBPGR at the IRRI India Office in New Delhi.

Under the agreement in principle, IRRI and ICAR will promote cooperation in the evaluation of Indian rice germplasm for nutritional traits and major agronomic attributes, exchange of high-value rice germplasm including specialty rice, capacity building and sharing of laboratory and field facilities, and development and implementation of collaborative research projects on mutually agreed areas.

The LoI is within the purview of the existing Memorandum of Agreement between ICAR and IRRI of 1974. Additionally, it aligns with the IRRI-ICAR Work Plan 2023 to 2027 signed by the respective director generals on 19 April 2023. "Under the work plan signed in April this year, NBPGR and IRRI have come together with common objectives to promote and accelerate progress in the joint evaluation of Indian rice germplasm for high-value traits and major agronomic attributes." Dr. Gyanendra Pratap Singh stated. "I am hopeful that this agreement will also facilitate international academic and research linkages, and provide mutual support for access to research and training in various disciplines of agricultural research."

Dr. Sudhanshu Singh explained the implementation of the cooperative strategy under the agreement.

"On behalf of IRRI, I would first acknowledge the support and cooperation that we have received from the Government of India over time," he said.

"I am confident that today's agreement will help both organizations to venture into new possibilities and opportunities to boost research and development of rice germplasm augmentation and utilization in India," Dr. Sudhanshu Singh added.

Also present at the ceremony were ICAR-NBPGR Officials, Dr. Rakesh Singh, head of the Division of Genomic Resources, and Dr. Raj Kumar Chauhan, principal scientist at the Division of Genomic Evaluation.

ACTIVITIES AT A GLANCE



Hyderabad, October 09-13, 2023

The National Remote Sensing Centre (NRSC) hosted an intensive five-day training program on hyperspectral remote sensing organized by Assam Agriculture University (AAU) in collaboration with IRRI under APART. NRSC is one of the primary centers of the Indian Space Research Organisation (ISRO), Department of Space (DOS) with the mandate of capacity building for professionals, faculty, and students. This specialized workshop focussed on building the in-house capacity of the scientists and teaching faculties from AAU attending the training program. The training aimed to provide a comprehensive understanding of hyperspectral remote sensing technologies, data processing techniques, and their diverse applications across various fields and get technical exposure for the generation of spectral libraries of different rice varieties.

ISARC Director Dr. Sudhanshu Singh presented his views and insights in his keynote lecture on "Opportunities in Big Data Analytics and ICTs to accelerate climate adaptation". He represented ISARC in a technical session on 'Climate Action for Sustainable Agri-food Systems' at the "XVI Agriculture Science Congress & ASC Expo". The session was chaired by DARE Secretary & ICAR DG Dr. Himanshu Pathak and NAHEP External Advisory Panel's National Member Dr. B. Venkateswarlu.



Kochin, Kerala, October 10-13, 2023



Nalanda, Harnaut, October 30, 2023

As part of the Value Stream Mapping (VSM) study under the Transforming Agri-Food Systems in South Asia (TAFSSA) project, a Stakeholders' Meeting was organized to help in conducting research study comprising interviews with the stakeholders of tomato food supply chain. IRRI team with members from Anglia Ruskin University and International Water Management Institute had discussions with KVK Harnaut team and farmers. The discussion revolved around the objective of the meeting which was to undertake the VSM study which involves mapping the food waste in the food supply chain focusing primarily on tomatoes and, impact of food waste across various stakeholders like farmers, traders, retailers, processors and transporters. The discussions led to gathering of information on various aspects of tomato food supply chain ranging from the major blocks of tomato production in Nalanda, soil type, types of variety grown, yield, irrigation facilities, storage, annual production, investment, pricing, selling to traders and consumers, transportation, challenges faced by farmers, trainings given to farmers etc.

An exposure visit/ traveling seminar was organized on mechanized DSR for 30 postgraduate students of Odisha University of Agriculture and Technology under the DSR-Odisha/CSISA Project. The group visited DSR-cluster demonstrations at Danpur, Benupada (along with adaptive trials), and Ramachandrapur villages of Delang block and interacted with the farmers at the spot. The participants also learned the parts and functions of quality multi-crop planters at Benupada. It was followed by a presentation on the "Project progress so far and key insights", a poster presentation, and an interaction & feedback session.



Puri, Odisha, November 04, 2023



Puri, Odisha, November 22, 2023

A "State Level Traveling Seminar on Mechanized-DSR with System Approach" along with an interaction meeting was organized under the DSR-Odisha project. Around 127 participants (including 25 female participants) from Odisha University of Agriculture & Technology, National Rice Research Institute, Department of Agriculture, DSR-Odisha and CSISA Project team, Bayer CropScience, Reliance Foundation, NGOs and progressive DSR-User farmers & service providers were present in this training session. They visited clusters (25-75 acres) of Mechanized-DSR at Sujana Puri and Ramachandrapur (Delang) and Mangarajapur and Sampur villages of Pipili block in Puri district. An interaction meeting was also organized at Sampur and in Sapphire Plaza, Bhubaneswar to collect feedback and chalk out future programs.

ISARC's Innovative Breeding unit organized a comprehensive 7-day training program on "Innovative Breeding for Crop Improvement." 15 students representing esteemed institutions such as Banaras Hindu University (BHU), Rani Lakshmi Bai University (RLBU), Jhansi, and Sam Higginbottom University of Agriculture, Technology, and Sciences (SHUATS) in Allahabad and Veer Bahadur University, Jaunpur participated in the event. The training program aimed to equip the next generation of agricultural scientists with cutting-edge knowledge and hands-on experience in innovative breeding techniques to enhance crop productivity and resilience in the face of evolving global challenges. The hands-on training sessions allowed participants to apply theoretical concepts in a practical setting, gaining valuable experience in the use of advanced tools and technologies in crop improvement.



Varanasi, November 21-28, 2023

To strengthen the capacity of machine operators associated with Farmers' Producer Companies (FPCs) at Custom Hiring Centres (CHCs) developed under APART in Morigaon and Cachar, a three-day training on postharvest management of combine harvesters, reaper and thresher was conducted by Assam Agriculture University(AAU) in collaboration with IRRI. A total of 32 participants from two Farmer Producer Companies (FPCs) took part (8 participants from Cachar district's Adarsha AG FPC and the remaining participants from Morigaon's Namami FPC). FPC members were encouraged to actively participate and acquire good technical knowledge on the repair and maintenance of the postharvest machinery from the experts.



Assam, November 20-22, 2023



Guwahati, Assam, November 30, 2023

IRRI and Fair Climate Fund (FCF) convened an inaugural design consultation meeting to initiate a project that will support the scaling-up of alternate wetting and drying (AWD) for boro rice production in Assam. The project, "GHG reductions with better irrigation practices in rice production," is being supported by the Government of Assam (ARIAS society) and is designed as per the Gold Standard methodology. IRRI will be a technical partner and will develop a package of practices and provide training of master trainers to build the capacity of farmers to adopt more efficient water management practices. The goal of this project is to provide a way for farmers in Assam to reduce greenhouse gas emissions of boro season rice and obtain carbon credits for adopting AWD.

ISARC AT FAIRS AND EXHIBITIONS



Kanpur (October 08-10) : All India Farmers' Fair and Agro-Industrial Exhibition at Chandrashekhar Azad University of Agriculture and Technology

ISARC scientists presented interventions in the identification and development of Kalanamak landraces to Mr. Manoj Kumar Singh, Agriculture Production Commissioner / Infrastructure & Industrial Development Commissioner and Additional Chief Secretary to Govt. of Uttar Pradesh and Vice-chancellor, CSAU.

Banda (October 26-28): Kisaan Mela at Banda University of Agriculture & Technology(BUAT)

Farmers observing the latest innovations and developments in rice research at ISARC's exhibition stall. Government of UP Jal Shakti Minister Ramkesh Nishad, BUAT Vice Chancellor Dr.N.P.Singh, BUAT Director Extension Dr. N.K.Bajpai, BUAT Registrar Dr S.K.Singh visited the stall.





Varanasi (November 02): Kisan Mela organized at Collectry Farm by Department of Agriculture

Varanasi Rohaniya region MLA Dr. Sunil Patel with officials of Agriculture Department interacting with ISARC scientists in the event.

VISITS AT ISARC



October 16: *Dr.M.Raveendran, Dr.S.Pazhanivelan and Dr. P.Balasubramanian from Tamil Nadu Agricultural University, (TNAU) Coimbatore in plant and soil laboratory at ISARC.*



November 06: *Dr. Michael Riemann from Karlsruher Institut für Technologie (KIT), Germany and Dr. Vaidurya Pratap Shahi from Sam Higginbottom University of Agriculture, Technology And Sciences (SHUATS), Prayagraj with ISARC officials.*



November 07: IRRI Genebank Head Dr. Venuprasad Ramaiah at experimental farm area in ISARC.



November 18: IFFCO officials Dr. Tarunendu Singh, Mr. Abhimanyu Rai, Mr. S K Verma, Mr. Rajendra Yadav DGM at nano fertilizers experiment fields in ISARC



December 01: *Dr. S. K Pattnayak Member of the Central Administrative Tribunal and former Secretary, Ministry of Agriculture and Farmer Welfare (MoA&FW), Government of India and Dr. Prof. Dimkic, from the Faculty of Biology, University of Belgrade, Belgrade, Serbia, visited ISARC. Dr. S. K Pattnayak also inaugurated table tennis area and food vending machine for ISARC employees.*

ANNOUNCEMENTS

Unveils the Science Behind Consumable Rice through series of micromodules

To enhance awareness and promote healthier dietary choices, the CEIRD team is delighted to announce the launch of the first module, "The Health Impact of Rice," in this six-module series. This series underscores the critical importance of controlling carbohydrate intake, especially for individuals managing diabetes. As part of this groundbreaking initiative, the spotlight is on low-GI (Glycemic Index) rice varieties, as well as whole grain and pigmented rice. These alternatives not only offer a diverse and flavorful culinary experience but also hold the promise of delivering potential health benefits.



Digital Badges Now Available for "Empowering Agriculture using Solar Irrigation Resilience" Micromodule Series!



CEIRD Introduces Digital Badging System for Micromodules. It starts with the micromodule series, "Empowering Agriculture using Solar Irrigation Resilience,". You can now exhibit your skills and accomplishments through visually striking digital badges. Visit our online learning platform at openlearning.cgiar.org, complete our micromodule series and claim your digital badge NOW!! Happy Learning!!

Launching of micromodule series on Management of Rice Disease by end of December



CEIRD announced the upcoming launch of our Micromodule Series on the "Management of Rice Diseases." This comprehensive series is crafted to provide participants with profound insights into the ecological management of diseases affecting rice cultivation.

FEATURED PUBLICATIONS

Elsevier, Farming System, Volume 2, 2024, Article 100068

Submergence-tolerant rice varieties and mechanical transplanting for intensification of rice-rice cropping systems in Assam

P Panneerselvam., Singh K., Borgohain R., Khandai S., Varkey L.M., Kumar V., Kumar V., Pathak, K., Kumar V., Singh S., Bhattacharya A., Kumar V.



Plant Biotechnology Journal, 2023

SpeedFlower: a comprehensive speed breeding protocol for indica and japonica rice

Kabade, P.G., Dixit, S., Singh, U.M., Alam, S., Bhosale, S., Kumar, S., Singh, S.K., Badri, J., Varma, N R G., Chetia, S., Singh, R., Pradhan, S.K., Banerjee, S., Deshmukh, R., Singh, S.P., Kalia, S., Sharma, T.R., Singh, S., Bhardwaj, H., Kohli, A., Kumar, A., Sinha, P. and Singh, V.K.





Elsevier, LWT, Volume 186, 2023, Article 115245

Enriched nutraceuticals in gluten-free whole grain rice cookies with alternative sweeteners

Itagi, H. B., Sartagoda, K. J. D., Gupta, N., Pratap, V., Roy, P., Tiozon Jr, R. N., ... & Sreenivasulu, N





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