



Recent Advancements in Black Rice Cultivation in North-East India

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Black rice or Chakhao, is already well known in North East India, particularly in Manipur, and is a crop with nutritional value and social significance due to its high anthocyanin content, antioxidant properties, low GI, and essential micronutrients. The old landraces were tall, lodging-prone, photoperiod-sensitive, and low-yielding (1.5–2.0 t ha⁻¹), although they were good in terms of health, which decreased their commercial application. Scientific interventions have recently changed their cultivation. A major breakthrough came when RC Manichakhao-1 release breed first introduced in 2025 by the ICAR Research Complex of NEH Region, featured a semi-dwarf, explosion resistant, and high yielding variety (4.5–5.0 t ha⁻¹) bred with the help of molecular markers and other breeding methods and did not lose its nutritional and aromatic characteristics. Agronomic methods like System of Rice Intensification (SRI) and precision organic nutrient management have been used better resulting in improved productivity and climate resiliency. There is a growth of the market potential by the value-added processing technologies. This has rendered black rice as a sustainable yet climate sensitive and economically viable super product in the North East India market and in the world at large.

Keywords: Black Rice, Nutritional Value, Photoperiod Sensitive, RC Manichakhao-1

The black rice was surrounded with exclusivity over centuries. It was infamously referred to in ancient China as “Forbidden Rice” and it was the “Emperor's” prerogative to make sure that he was able to live as long as he could and remain very healthy. Parallel to this, in the fertile waving lands of Northeast India, and specifically in the state of Manipur, black rice has been growing for thousands of years. Traditionally referred to as *Chakhao* (meaning delicious rice), it has long been a highly sacred crop, and the main dish of the community feasts, traditional medicine and native cultural practices. But over a long period of time, *Chakhao* was an agronomic paradox. It was, however, a nutritional giant, but a nightmare to the farmer: too tall, easily toppled by the wind, brought in very little grain, and was very prone to airborne diseases. Move to the modern world and the story is very different. With a worldwide demand on functional production of superfoods and supported by the latest agricultural research, the North East Indian region is now undergoing a “Purple Gold” revolution. Since its genetic construction was outlined in the mapping, to the publication of the revolutionary high-yielding varieties in 2025, science and tradition are coming together to make black rice a global competitive and climate-adaptive cash crop that has a regional heritage.

Agronomic Challenge and Heritage

- **Historical Significance:** Black rice has been cultivated in North East India (particularly Manipur) for millennia and is regarded locally as *Chakhao* ("delicious rice" and the key component of indigenous feasts and folk medicine).
- **Traditional Bottleneck:** The nutritional quality was not a prerequisite, but the traditional landraces (such as *Chakhao poireiton*) were photoperiod-neutral and over-vigorous (>150 cm).
- **Lodging Problem:** The great height of the crop was very prone to lodging (collapsing under wind/rain) and hence had poor traditional yields of only 1.5 to 2.0 tonnes per hectare.

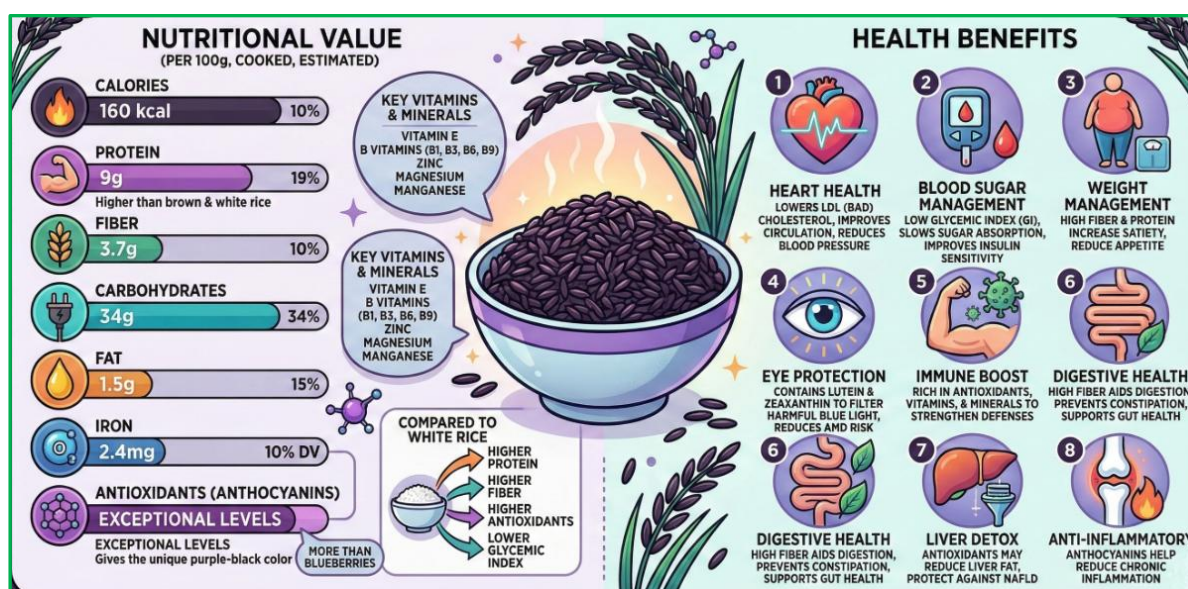


Fig.1: Nutritional value and health benefits of black rice

Wealth of Nutrition and Phytochemical Excellence

- **High Anthocyanin Content:** The purple-black color is due to anthocyanins, namely cyanidin -3-O -glucoside (C3G) and peonidin -3-O -glucoside (P3G). There are lines of *Chakhao* with up to 740 mg/kg, which are as antioxidant as blueberries.
- **Functional Superfood:** Black rice is neutral and counteracts reactive oxygen species (ROS), has a low glycemic index (good with diabetics), and is naturally gluten-free, as well as rich in zinc, iron and 18 essential amino acids.

Breaking the Yield Ceiling: Genetics of *Chakhao* of the day

Although *Chakhao* was nutritionally superior, the conventional farming of the crop was associated with inefficiencies. Native landraces like *Chakhao poireiton* and *Chakhao amubi* were photoperiod sensitive and grew to very high heights, most of which were above 150 centimeters. This high architecture rendered the plants very vulnerable to lodging, a situation where the heavy, grain filled stalks break down due to the weight of the wind or down pour resulting in colossal losses of crop. Therefore, the yield of traditional was only 1.5 to 2.0 tonnes per hectare. The turning point has been reached recently with the help of specific genetic interventions. Plant geneticists and breeders realized that they must modify the physical architecture of black rice, that is, without compromising its biochemical content, in order to make it commercially viable.

Breakthrough 2025: RC Manichakhao-1

The agricultural innovation in the region hit an all-time high in June 2025. ICAR Research Complex for NEH Region Manipur Centre officially released RC Manichakhao-1, the first High-Yielding Variety (HYV) of black rice in India. This variety was developed by Dr. Konsam Sarika and her group of geneticists:

- **Semi-Dwarf Architecture:** The height of the plant has been made very low through the incorporation of dwarfing genes. This solid sturdy building almost does away with the issue of lodging, and therefore the plant can sustain the severe winds of the monsoon.
- **Doubled the Yield:** RC Manichakhao-1 is an amazing 4.5 -5.0 tonnes per hectare yield, nearly twice the traditional landraces.
- **Maintained Integrity:** It was also important that the genes that are causing the high contents of anthocyanins, the mild nutty flavor and the unique aroma are maintained using molecular marker-assisted selection.

Genetic Innovations: Breaking the Yield Ceiling

- **HYV Breakthrough:** In 2025, the ICAR introduced RC Manichakhao-1, the first black rice with High-Yielding Variety (HYV) in India.
- **Semi-Dwarf Architecture:** With the success of the introduction of dwarfing genes, scientists made a thick plant that does not easily lodge and can withstand monsoon winds.
- **Doubled Productivity:** RC Manichakhao-1 yields 4.5 to 5.0 tonnes per hectare, over 2 times higher than conventional yields, without compromising distinctive aroma and phytochemical profile by molecular marker-assisted breeding.
- **Disease Resistance through Gene Pyramid:** Breeders piled the *Pi54* (universal blast resistance) and *OsSPL14* (optimal plant architecture) genes into the native lines resulting in the development of strong resistance to the malicious Rice Blast fungus.

Climate-Resilient and Organic Agrotechnology

The North East part of India is more of an organic agriculture center by default and design due to lower productivity of synthetic fertilizers. As a way of realizing the potential of the new high-yielding genetic lines, agronomists are also transforming field practices by simultaneously combining a conventional organic ethos with precision agriculture.

- **System of Rice Intensification (SRI)**

The farmers are moving towards the System of Rice Intensification (SRI) as opposed to traditional flooded-field broadcasting. SRI entails the planting of younger seedlings in those places with spacing in between and keeping the soils wet instead of being constantly in floods. The practice is much better in terms of developing the roots and also in stimulating aggressive tillering (generation of side shoots). Applied to black rice, SRI has demonstrated an improvement in panicle length and grain filling that is multiplied many times over and saves water, which is a crucial change in the face of more and more unpredictable rainfall patterns caused by climate change.

- **Accuracy Organic Nutrient Management**

Due to the fact high yielding varieties are in need of more nutrients, researchers have streamlined the management of organic potash and nitrogen to sustain *Chakhao* without using synthetic chemicals. The recent agronomic experiments (2024-2025) have established that banana pseudo-stem vermiculite use in combination with Azolla (a nitrogen-fixing aquatic fern) and mustard oil cake provides the greatest Absolute Growth Rate (AGR) and duration of leaf area in black rice. These locally-grown bio-inputs do not only preserve the organic quality of the crop but also enhance the soil microbiomes, resulting in the sooner flowering and the maturity of the grain.

Food Engineering and Value Addition

The harvesting of the grain is not the only step in the value chain. The traditional black rice is glutinous and it is much more difficult to cook compared to white rice as the bran layer is not polished. In order to seize the contemporary consumerist market that is fast-paced, North East Indian black rice is undergoing the innovative processing technologies.

- **Ultrasonication for Industrial Applications**

Isolating Black Rice Protein Concentrate (BRPC) in order to derive the best out of the crop. In the recent past, high-power ultrasonication—which involves the use of high-frequency sound waves on the protein concentrate by food engineers has started to be applied.

The physical aspects of this acoustic cavitation include the change in the second structure of the rice proteins (altering the proportions of the alpha-helices and the beta-sheets). This leads to a drastic effect of high surface hydrophobicity and solubility of the protein. Practically, this makes black rice protein a highly efficient, plant-based natural emulsifier, and that is incredibly useful to the pharmaceutical and vegan food industries.

• Popping, Puffing, and Instantization

In order to cater to the demand of convenient and healthy foods, scientists have optimized the thermodynamics of gun-puffing and popping on glutinous black rice. The thick endosperm of the black rice swells quickly with a fine regulation of the initial moisture content (preferably about 14%), as well as with the use of pressure-puffing vessels. This is a physically modified, highly porous grain being utilized to produce gluten-free instant rice noodles, bioactive snack bars, and ready to eat breakfast cereals which still maintain their phenolic contents and antioxidant capability even with the thermal processing.

Table 1. Comparison between Traditional *Chakhao* Landraces and Improved Variety (RC Manichakhao-1)

Parameter	Traditional <i>Chakhao</i> (e.g., <i>Chakhao poireiton</i> , <i>Chakhao amubi</i>)	RC Manichakhao-1 (HYV, 2025)
Plant Height	>150 cm (Tall)	Semi-dwarf ($\approx 100\text{--}110$ cm)
Lodging Resistance	Highly susceptible	Highly resistant
Photoperiod Sensitivity	Sensitive	Less sensitive / adaptable
Average Yield	$1.5\text{--}2.0\text{ t ha}^{-1}$	$4.5\text{--}5.0\text{ t ha}^{-1}$
Anthocyanin Content	High (up to 740 mg kg^{-1})	Maintained high levels
Disease Resistance	Susceptible to blast	Pi54 gene-mediated blast resistance
Plant Architecture	Vigorous, weak stem	Strong stem (OsSPL14 gene)
Commercial Viability	Limited	High

Socio-Economic Impact

- **Geographical Indication (GI) Tag:** In 2020, the GI tag was granted to the geographical identity of Manipuri Black Rice and valued it to a high-value global product.
- **Export and Profitability:** With the help of such agencies as the Manipur Organic Mission Agency (MOMA), organic *Chakhao* is no longer sold via middlemen, instead receiving the highest international retail prices and radically altering the economic life of the North East Indian farmers.

"The transformation of Chakhao is a textbook example of how indigenous biodiversity, when validated and enhanced by modern science, can rewrite the economic destiny of a region."

Moreover, the bibliometric environment suggests an academic boom all over the world. Studies conducted on *Chakhao*, that had been barely reported in the foreign literature 20 years ago, are now finding extensive application in fields such as molecular biology to phytochemistry. Such a steady stream of research capital and interest also means that North East India is going to be the centre of innovation with black rice decades to come.

Conclusion

Recent breakthroughs in the cultivation of black rice in North East India can be viewed as a perfect example of the development of agriculture. Depleted the real potential of the crop by adhering to cultural heritage and nutritional sanctity of the native *Chakhao*, and in the process of forcefully removing the biological constraints of the crop by progressing using modern

genetic science such as the semi-dwarf RC Manichakhao-1. A combined with climate-resistant organic agriculture methods and innovative food engineering, black rice is no longer one of the relics of the past, a ritualized moment. It is a very lucrative, sustainable and scientifically optimized superfood for the future one that is set to feed the world consumer with economic stability to the North East Indian farmers.

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