

# Aerobic dry direct-seeded rice

## A sustainable approach in rice cultivation

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*Sustainable development amidst global climate change has been the topic of discussion on all scientific fronts. Agriculture practice and goals for research should also focus on sustainable goals like preserving soil health, increasing water productivity, minimizing environmental pollution, etc. This article highlights the advantages and the need to adopt the aerobic system of rice cultivation over the ongoing transplanted system of cultivation. This would not only save a huge amount of water but also help reduce the emission of greenhouse gas like methane and at the same time reduce nutrient losses. Suitable aerobic varieties such as CR Dhan 200, CR Dhan 201, CR Dhan 202, CR Dhan 203, CR Dhan 204, CR Dhan 205, CR Dhan 206, CR Dhan 207, CR Dhan 209 and CR Dhan 210 developed at this Institute need to be popularized and should be adopted by the farmers for sustainability in rice cultivation.*

**Keywords:** Aerobic rice, Direct-seeded rice, Input use efficiency, Water use efficiency

**I**N recent times, water scarcity is emerging as a global crisis. In such a scenario, diverting a large volume of freshwater towards agriculture use puts us at crossroads. Water availability will be a serious constraint in achieving the food requirements projected for 2030. The need for water for agricultural consumption is likely to be greater than currently anticipated, and the available supply of it is less than the projected demand. Groundwater over-drafting, salinization of soils, and re-allocation of water from agriculture to urban settlements will lead to water scarcity for irrigation and crop production in many important food-producing pockets. In Asia, irrigated rice is one of the most important agricultural ecosystems in rice and shares one of the highest areas of both consumption and production. Additionally, Asia alone consumes 90% of the freshwater diverted to agriculture in the whole world. Ongoing transplanted system of rice cultivation consumes around 3,000-5,000 liters

of water to yield 1kg of rice. This system of rice cultivation is also contributing methane, a greenhouse gas from the fields, which accounts for 11% of the total anthropogenic methane emissions in the world. Apart from these factors, continuous standing water in the field leads to a loss in nitrogen, and most of the phosphorus becomes unavailable to the plant. These factors will soon be a burden, especially in India where rice regulates the national food security and meets the nutritional demand of the country. This realization has steered the farm scientists and breeders in the direction to develop an alternative to increase water and nutrient use efficiency without compromising the yield and consumption pattern.

Aerobic dry direct-seeded rice cultivation offers a solution to the above problems. The International Rice Research Institute (IRRI) developed aerobic rice technology to address the water crisis, mainly in tropical agricultural countries. In this

system of rice crop management, the crop bypasses the nursery growth stage, instead, it directly establishes in a non-puddled and non-flooded field similar to an upland crop. The idea behind the term aerobic rice is to sustain an unsaturated aerobic condition of the soil in place of the flooded anaerobic condition. This relies on the efficient management of water (inflows and outflows) with minimal loss suiting to the critical stages of crop growth. Suitable for varieties with high response to inputs, China has already reported the water consumption as to be 55-56% lower than that required in the flooded rice, raising the water productivity 1.6-1.9 times higher. Aerobic rice also addresses the situation of labour shortage, as the requirement is very less compared to its counterpart. These factors of low water requirement, low labour cost, lower nutrient loss, etc., ultimately decrease the input cost of the farmers.

### Conception and development of aerobic rice system

In the eastern regions of India, the direct seeding method of rice establishment was the common practice in most of the upland and rainfed shallow lowlands of Chhattisgarh, Odisha, Jharkhand, eastern Uttar Pradesh and Bihar. Rice was generally broadcasted with a higher seed rate, a month before the onset of monsoon, the crop at 25-30 days would then be subjected to beushening, a practice to control weeds and thin out the crop using a cross plough technique. The introduction of semi-dwarf rice varieties and gradual adoption of the transplanting method led to a decline in the DSR method and the local landraces/ upland varieties slowly started to disappear from farmers' fields. But with an increase in labour shortage, the existing water crisis has compelled many countries to realize the significance of turning back to direct seeding, particularly in Asia. The initiative by IRRI, Philippines to breed rice varieties suited to aerobic conditions in south Asian countries like India, Nepal, Bangladesh, Pakistan and Philippines under the project 'Developing and disseminating water saving rice technologies in South Asia' (ADB RETA 6276) has paved the way for further research in this field (Fig. 1).

In India, ICAR-NRRI, Cuttack breeding activities started in 2007 that focused on developing aerobic cultivars mainly through hybridization of high-yielding irrigated rice varieties with drought-tolerant lines. This program was assisted by several segregating populations, fixed lines and varieties introduced from IRRI, Philippines. Within a short period, many high yielding lines were developed and entered the AICRIP trials for their release. The variety Apo, earlier released in the Philippines, was found suitable for Indian climatic conditions also and subsequently released as CR Dhan 200 by the Odisha State Sub-Committee on Crop Standards, Notification, and Release of Varieties during 2012. A brief description of all the varieties released from NRRI, Cuttack along



Fig. 1. Aerobic dry direct-seeded plot with no standing water.

with their characteristics has been mentioned in the following section.

#### CR Dhan 200 (Pyari)

The first aerobic rice variety from NRRI, Cuttack was released for aerobic uplands of Odisha from a cross between UPL RI 5 and IR12979-24-1 (Brown) in 2012. It is a semi-dwarf variety (95-100cm) of 115-120 days duration with an average yield of 4.5t/ha (test weight is 24g) with a potential yield as high as 6.9 t/ha. It bears 7-10 tillers per plant and the average numbers of panicles are 272 per m<sup>2</sup> with short bold grains. This variety has no grain chalkiness, intermediate alkali spreading value (4), intermediate amylose content (21.8%), L/B ratio of 2.33, and high milling recovery (68%). CR Dhan 200 is moderately resistant to diseases like blast, neck blast, brown spot, sheath blight and pests like leaf folder and gall midge (Fig. 2).

#### CR Dhan 201

This variety was developed from the cross between IR72022-46-2-3-2 and IRRI 105 and was released in 2014 for cultivation in the areas of Bihar and Chhattisgarh. It is a semi-dwarf variety (95-100cm) of mid-early duration (118 days), yield up to 7.14 t/ha with an average yield of around 3.8-4.0 t/ha (test weight is 25.5g) with 305 panicles per m<sup>2</sup> and each plant bears 7-10 tillers. The variety has long slender grains, low

alkali spreading value (6.0), no grain chalkiness, intermediate amylose content (24.45%), L/B ratio of 3.06, and high milling recovery (60%). It is moderately resistant to blast, sheath rot, sheath blight, and leaf folder.

#### CR Dhan 202

CR Dhan 202 is derived from a cross between IRRI 148 and IR78877-208-B-1-1 and was released in 2014 for cultivation in the states of Jharkhand and Odisha. It is semi-dwarf (100-105cm), pigmented base, mid-early duration (115 days) and yield up to 6.81 t/ha with an average yield of around 3.7-4.5t/ha (test weight is 21.3g). The average number of panicles is 285 per m<sup>2</sup> with 7-10 tillers per plant. The grains are long bold with no grain chalkiness, lowalkali spreading value (4.0), intermediate amylose content (17.93%), L/B ratio of 2.65, and milling recovery of 68.5%. It is moderately resistant to brown spot, sheath rot, sheath blight, leaf folder.

#### CR Dhan 203 (Sachala)

The variety is derived from a cross between IR78877-208-B-1-1 and IRRI 132 and was released for cultivation in the states of Odisha, Maharashtra and Madhya Pradesh under aerobic/ water limiting system in 2014. It is a mid-early duration variety (110 days) with plant height of 100 cm producing up to 6.59t/ha



Fig. 2. Field view of CR Dhan 200 (Pyari).

with an average yield of 4.05t/ha (test weight of 24.6g). The variety bears 7-9 tiller per plant and 225 panicles per m<sup>2</sup>. The grains are long slender, occasionally chalky, intermediate alkali spreading value (4), intermediate amylose content (22.54%), L/B ratio of 3.16, and milling recovery of 66.85%. The variety is moderately resistant to leaf blight, brown spot, sheath rot, sheath blight and leaf folder.

#### CR Dhan 204

CR Dhan 204, a derivative of the cross between IRRI 76569-259-1-2-1 and CT 6510-24-1-2, was released in 2019 for Jharkhand and Tamil Nadu for the early aerobic system. The duration of this variety is 120 days with plant height of 95-100cm producing up to 6.48t/ha with an average yield of 4.2t/ha (test weight is 21.3g). It bears 7-10 tillers per plant and the average number of panicles is 280 per m<sup>2</sup>. The grains are long bold, occasionally chalky, lowalkali spreading value (3.0), intermediate amylose content (22.24%), L/B ratio of 2.78, and milling recovery of 66.5%. It is moderately resistant to neck blast, brown spot, sheath rot, leaf folder, leaf blast, and good grain quality.

#### CR Dhan 205

This variety is derived from the

segregating lines of the cross between N22 and Swarna. Released in 2019, it is suitable for cultivation in the states of Tamil Nadu, Gujarat, Odisha, Madhya Pradesh and Punjab under the early aerobic system. It is a semi-dwarf (100-105cm), medium duration variety (110 days) bearing 6-9 tillers per plant and 230-300 panicles per m<sup>2</sup>. It produces up to 6.94t/ha with an average yield of around 3.7-4.5 t/ha with test weight of 24.5g. It has short bold grains, occasionally having grain chalkiness, low alkali spreading value (6.5), intermediate amylose content (22.29%), L/B ratio of 2.46, milling recovery of 69.9%. The variety is moderately resistant to leaf blast, brown spot, sheath rot, stem borer, and leaf folder.

#### CR Dhan 206 (Gopinath)

CR Dhan 206 is developed from a cross between Brahmanakhi and NDR9930077 and was released in 2014 for cultivation under aerobic conditions of Odisha. A semi-dwarf (97-107cm) variety of mid-early duration (115days) produces up to 4.91 t/ha with an average yield of 3.95t/ha, having test weight of 22.68g. The plant bears 8-10 tillers and the average number of panicles per square meter is 290-323. The grains are short bold with high milling recovery (70.8), intermediate

amylose content (24.27), intermediate grain chalkiness, L/B ratio of 2.36, and intermediate alkali spreading value (4). It is moderately resistant to leaf blight, brown spot, sheath rot, sheath blight and leaf folder.

#### CR Dhan 207 (Srimati)

This variety was released in 2016 for cultivation in Odisha under the early aerobic system. Derived from a cross between IR71700-247-1-1-2 and IR57514-PMI 5-B-1-2, the variety is of mid-early duration (110-115days) with a plant height of 95-100cm. It bears 6-9 tillers per plant and 240-290 panicles per m<sup>2</sup>. The grains are characteristically medium slender with a test weight of 24g, it produces upto 7.08t/ha with an average yield of 3.7t/ha. The grains have high milling recovery (69.5%), occasionally grains have chalkiness, alkali spreading value of 3.5 and intermediate amylose content (22.62) and L/B ratio of 2.62. This genotype is moderately resistant to blast, neck blast, brown spot, sheath rot, sheath blight, leaf folder, green leafhopper and gall midge.

#### CR Dhan 209 (Priya)

This variety was generated from a cross between IR72022-46-2-3-3-2 and IRRI 105 and was released in 2016 for cultivation in Odisha under the irrigated aerobic system. It is a mid-early duration variety of 112-115 days with plant height of 95-100cm in length. It gives up to 7.84t/ha with an average yield of 4.0t/ha and the test weight is 24g. The grain is long slender with high milling recovery (77.95), occasionally grains have chalkiness, alkali spreading value (3.5) and intermediate amylose content (23.17), L/B ratio of 3.46. The variety is moderately resistant to blast, neck blast, brown spot, rice tungro virus, sheath blight, leaf folder and white back plant hopper.

#### CR Dhan 210

The elite line CR Dhan 210 was developed from the cross between IR717002-247-1-1-2 and IR77080-B-34-1-1 in 2019, suitable for cultivation in Odisha for the early

aerobic system. The plant height is 95-105cm, while the duration is around 110-115 days. There are 6-9 tillers per plant and 204-290 panicles per meter square. The yield is upto 7.8t/ha with an average yield of 3.0-4.5t/ha and the test weight is 24g. The grains are long slender with high milling recovery (70.1), occasionally grain chalkiness, alkali spreading value 3.5 and intermediate amylose content (21.99), and L/B ratio of 3.34. This variety is moderately resistant to leaf blast, neck blast, brown spot and sheath rot, stem borer (both dead heart and white ear heads), leaf folder and green leafhopper.

All these varieties have been performing well in their respective ecologies with the recommended package of practices but there is still a need to improve their yield on par

with irrigated rice. Aerobic rice when grown under dry direct-seeded conditions becomes prone to different kinds of stresses like drought, lodging, nutrient deficiency, disease and pest incidence, etc. To mitigate such a situation, NRRI in collaboration with IRRI has been involved in a research program to improve the high yielding varieties suitable for aerobic dry DSR conditions in QTL multi-stacking experiment using 12 different donor lines for 19 different QTLs. The objective was to introgress 19 reported QTLs related to 10 different traits that included anaerobic germination (*qAG9.1*, *qAG9.2*), early uniform emergence (*qEUE 11.1*), early vigour (*qEUV 9.1*), nutrient uptake enhancement through higher root length density (*qNR 5.1*, *qRHD 1.1*), nodal root (*qNR5.1*), lodging resistance (*qLDG 3.1*, *qLDG 4.1*),

grain yield (*qGYD 1.1*, *qGYD 6.1*, *qGYD 9.1*, *qGYD 10.1*), gall midge (*Gm4*, *Gm8*), brown plant hopper (*BPH3*, *BPH17*) and blast (*Pi9*). A pair wise crossing program was designed to facilitate the multi-QTL stacking program. These intercrosses' true F1s were hybridized among themselves to produce the intercrossed hybrids. Only the hybrids with more than six QTLs were carried forward. By *Kharif 2020*, 14 QTLs have been assembled in the background of Lalat MAS and CR Dhan 304. These initiatives will help in increasing adaptability, decrease the input cost and popularity among the farming community, and will help in bringing aerobic rice cultivation to the mainstream.

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## HANDBOOK OF INTEGRATED PEST MANAGEMENT

To reverse the loss of environmental resources and also to reduce biodiversity loss, the Government of India has Integrated Pest Management (IPM) as part of the National Agricultural Policy. Integrated Pest Management emphasizes the growth of a health crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms. IPM is not new – mechanical, cultural and biological tactics were used by farmers for hundreds of years before chemical pesticides became available. Besides, there are IPM techniques that have been developed more recently and are effective in suppressing pests without adversely affecting the environment.



The task of spreading the message of IPM across is tough due to poor awareness about the subject among people in line-departments as also among the farmers. The information on integrated pest management as a whole is scattered. This *Handbook* comprehensively deals with all the aspects of integrated pest management in field crops, horticultural crops under traditional, protected systems. Information on basic strategies and tactics of different methods of management including mass production of biocontrol agents, IPM policy and pesticide registration is provided in comprehensive form.

The *Handbook of Integrated Pest Management* comprises 82 chapters which are well written in lucid language with crispy sentences by the renowned scientists. The role of IPM is elucidated with different pests like *Trichogramma*, *Bacillus thuringiensis*, *Nomuraea rileyi* etc. and agricultural crops like rice, wheat, maize, sorghum, pearl millet, pulses, soybean, rapeseed mustard, groundnut, minor-oilseed crops, sugarcane, cotton, jute and mesta, potato, vegetable crops, fruits, grapes, citrus, banana, pomegranate, coconut etc. This *Handbook* will provide information of available useful technologies to educate on how to reduce or judiciously use chemical pesticides, safeguard ourselves from chronic poisoning, save the National environment while also reducing input costs and raise farmers' income. This compilation will be useful to teachers, students, trainers, line-department personnel and policy makers.

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