

Rice cultivation in the submergence and drought-prone environments by adapting climate-smart varieties

S K Pradhan¹, E Pandit², P Sanghamitra¹, J Meher¹, A Anandan¹, R P Sah¹, S K Dash¹ and S R Das³

Orissa University of Agriculture and Technology, Bhubaneswar, Odisha 751 003

Rice is the staple food crop, providing global food and nutritional security for millions of peoples. India has the largest rice-growing area in the world but the production environments are diverse and challenging. The rainfed rice ecologies occupy about 45% of the rice area which is present mostly in the eastern region of the country. These rainfed ecologies face both abiotic (submergence, drought) and biotic (pest and diseases) stresses. The adverse effects of these stresses are intensifying with the emerging threats of climate change.

Keywords: Climate-smart rice variety, Drought-prone, Eastern India, Rice cultivation

THE IPCC in 2014 projected a change in climate-related events such as an increase in temperatures, heatwave, floods, drought, and uneven distribution of rainfall in the coming years. The anticipated change enhances the risk on food security due to aberrant stress. Rice crop is becoming the victim of the adverse effects of extreme events due to climate change such as drought and submergence stresses. The adverse effects of heat and cold waves, flooding, cyclones, hail storms are already known to affect timely rice cultivation and production. They are visible from different parts of the country. Agriculture, more particularly rice cultivation is the mainstay of the majority of the Indian population. The eastern region of our country is more vulnerable to the adverse effects of climate change. Monsoon rainfall in our country is becoming erratic as a result the risk of drought and flood damage to rice crops is increasing. Extreme events like the Super cyclone in Odisha in 1999, the effects of Hudhud and other cyclonic storms in Odisha and Andhra Pradesh are recent extreme events in this region.

The heatwaves in Andhra Pradesh and Telangana during 2016 and the cold waves of 2017 in Jammu & Kashmir are extreme effects of temperature-related issues faced in recent years. Also, the contribution of anthropogenic warming is on the rise for causing extreme events in precipitation in India.

Eastern India has low productivity of rice due to stress-prone ecology. To mitigate the gap in expected and actual yield in the field, a holistic approach starting from genetic improvement varieties to agronomic and pest management are highly essential. The concept of breeding climate-smart varieties or climate-resilient varieties is one of the viable solutions to sustain the productivity of rice in a stress-prone environment.

The development of climate-resilient varieties for tolerance to heat, drought, flooding, chilling and salinity stresses are essential to improve rice yields under adverse climatic challenges. It is essential to enhance the productivity and profitability of rice crops particularly by the development of climate-ready varieties for these stresses. Adaption of these climate-smart rice varieties

will improve the livelihoods of millions of people of the eastern Indian farming community associated with rice cultivation. Combining drought and flooding tolerance in the popular rice varieties Swarna and Sambha Mahsuri are the best example of a coping strategy against the adverse effect of both the stresses on rice productivity. The climate-smart varieties in the Swarna background have been developed by integrating molecular technology in the breeding program.

Climate-smart rice varieties for submergence and drought

ICAR-National Rice Research Institute (NRRI), Cuttack has developed two climate-smart varieties namely, CR Dhan 801 and CR Dhan 802 carrying submergence and drought tolerance QTLs in the background of popular variety 'Swarna'. These two varieties of achievements are unique and released recently vide Government of India notification on 19th February 2019. These varieties contain Sub1 QTL for submergence tolerance and drought yield QTLs viz., qDTY1.1, qDTY2.1, and qDTY3.1 for higher

yield under drought stress were combined in the Swarna variety background by adopting marker-assisted backcross breeding. Genome recovery of the recipient parent was more than 95%. These two varieties are weakly photosensitive and show 140-145 days average maturity duration. The varieties are resistant to stem borer (both dead heart and white ear), leaf folder, plant-hoppers, and case worm while moderately resistant to bacterial blight, sheath rot, and rice tungro virus. They have good hulling, milling, and head rice recovery like the recipient parent Swarna and possess intermediate amylose content, short bold grain, and other desirable grain quality parameters. Cultivation practices, diseases, and insect pests control as well as harvesting and processing of these varieties are similar to other commonly grown high-yielding varieties of rice.

CR Dhan 801

CR Dhan 801 carries submergence tolerance (Sub1) and drought 3 yield QTLs viz., qDTY1.1 + qDTY2.1 + qDTY3.1 in the popular variety background 'Swarna'. The variety is recommended for cultivation in Odisha, West Bengal, Andhra Pradesh, Telangana, and Uttar Pradesh. The variety was developed from the cross of IR81896-B-B-195/2*Swarna-Sub1/IR91659-54-35 by adopting a marker-assisted breeding approach (Fig. 1). CR Dhan 801 has tolerance to submergence for 2 weeks and also drought stress. The variety is weakly photosensitive with average maturity duration of 140-145 days. The variety has about 100 cm plant height. Average yield of the variety is 6,350 kg/ha under normal conditions and about 3,000 kg/ha under drought and submergence stress conditions. It produces short bold grain with a test weight of 20.6 g. CR Dhan 801 shows resistance to both dead heart and white ear heads for stem borer, leaf folder, and case worm. The variety is moderately resistant to bacterial blight and rice tungro virus. CR Dhan 801 has desirable qualities like good hulling, milling, head rice recovery, alkali spreading value, intermediate amylose content, and other cooking

Characteristics of variety, CR Dhan 801	
Characters	Remarks
Plant height (cm)	100
Flowering (days)	114
Maturity duration (days)	140
1000-grain weight (g.)	20.6
Lodging	Non-lodging
Panicle type	Intermediate
Panicle exertion	Well excreted
Hulling (%)	79.6
Milling (%)	69.9
Head Rice Recovery (%)	66.2
Kernel Length(mm)	5.15
Kernel Breadth(mm)	2.22
L/B Ratio	2.31
Grain type	SB
Grain Chalkiness.	VOC
Alkali Spreading Value	4.0
Amylose Content (%)	25.13
Gel Consistency (mm)	39
VOC: Very occasionally present	

and eating quality traits.

CR Dhan 802 (Subhas)

CR Dhan 802 (Subhash) carry submergence tolerance (Sub1) and two drought tolerant yield QTLs viz., qDTY2.1+qDTY3.1 in the popular variety background 'Swarna'. The variety is recommended for cultivation in Bihar and Madhya Pradesh. The variety is named Subhash, the legendary freedom born from Cuttack. The variety was developed from the cross Swarna-Sub1*4 / IR81896-B-B-195 by adopting a marker-assisted backcross breeding approach (Fig. 2). Selection, evaluation, and testing of the NILs were done at ICAR-National Rice Research Institute, Cuttack, Odisha with the objective to breed high-yielding variety with

tolerance to submergence and drought conditions. CR Dhan 802 was released in 2019. The average yield of the variety is 6,508 kg/ha under normal conditions and 2,344 kg/ha under drought stress conditions. CR Dhan 802 is weakly photosensitive and matures at about 140-145 days. The variety produces short bold grain which gives 19g seed test weight. The variety is resistant to stem borer (both dead heart and white ear heads), leaf folder, plant-hopper, and case worm while moderately resistant to bacterial blight, sheath rot, and rice tungro virus. Grains of the variety contain desirable quality traits like intermediate amylose content, short bold grain, and other good eating and cooking qualities.

Characteristics of variety, CR Dhan 802 (Subhash)	
Characters	Remarks
Plant height	100 cm
Flowering	116 days
Maturity duration	145 days
1000-grain weight (g.)	20.4
Lodging	Non-lodging
Panicle type	Intermediate
Panicle exertion	Well excreted
Hulling (%)	77.85
Milling (%)	70.2
Head Rice Recovery (%)	64.25
Kernel Length (mm)	5.0
Kernel Breadth (mm)	2.16
L/B Ratio	2.31
Grain type	SB
Grain Chalkiness.	VOC
Alkali Spreading Value	4.5
Amylose Content (%)	25.0
Gel Consistency (mm)	39.5
VOC: Very occasionally present	



Fig. 1. CR Dhan 801 at milking stage of the crop



Fig. 2. Panicles and kernels of CR Dhan 802

DRR Dhan 50 (IET 25671)

DRR Dhan 50 is recommended for cultivation in Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Bihar, Odisha, Chhattisgarh, Uttar Pradesh, and Madhya Pradesh. The variety is released by IIRR, Hyderabad in 2019. The variety

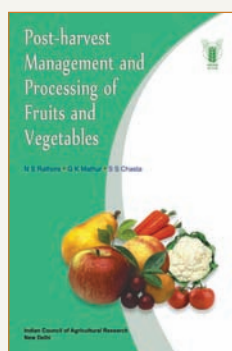
carries Sub1 QTL for submergence tolerance and 2 drought yield QTLs, qDTY2.1, and qDTY3.1 QTLs for yield under drought stress. The variety is similar in appearance to Sambha Mahsuri and was developed by adopting a marker-assisted backcross breeding approach.

Conclusions

The climate-smart varieties for drought and submergence stresses are very important in the present-day adverse effects due to climate change for adaptation. The adoption of climate-smart rice varieties in eastern India will increase rice production from the vulnerable lowland ecology for the increasing population. Concerted efforts during the last few years resulted in the development of climate-smart varieties in rice. These efforts need to be further strengthened to develop varieties infusing with multiple desirable stress tolerance traits as a genetic mitigation strategy under climate change. Those novel climate-smart varieties will play important role in mitigating the adverse effects of change in combination with better management practices in the future.

¹Crop Improvement Division, ICAR-NRRI, Cuttack-6, ²Bioscience and Biotechnology Department, FM University, Balasore 20, ³Department of Plant Breeding and Genetics. Corresponding email: directorcrricutack@gmail.com

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