Vol. 5 Issue- 4, December 2024 (e-ISSN: 2582-8223)

JUST AGRICULTURE
multidisciplinary e-Newsletter

Anoxia tolerance: Opulence confined to Rice, Key to DSR

Soumya Chakraborty[1] and Sayani Das[2]
[1]Ph.D. research scholar, Division of Molecular biology and biotechnology, ICAR-Indian Agricultural Research Institute, New Delhi
[2] Ph.D. research scholar, Division of Agronomy, Bidhan Chandra Krishi Viswavidyalaya, West Bengal

ARTICLE ID: 02

Introduction:

With the inescapable issue, global warming, the agricultural ecology is highly vulnerable to unexpected rain, causing significant flood or submergence stress to the crops. Especially when the rain comes just after seeding, that becomes a threat to the crop establishment or good crop strand and ultimately causes yield penalty. Fortunately, rice being semiaquatic plant, able to germinate and expand its coleoptile in anoxic-submergence condition compared to other cereals. Various studies showed that rice can breakdown its starch reserves during germination in anaerobic soils better than other cereals. Rice has genetic diversity to convert complex starch into simple carbohydrate under anaerobic condition during germination. Considerable research endeavors have been focused worldwide on comprehending the mechanism of submergence tolerance during the early vegetative stage of rice. Direct seeded rice (DSR) to be successful it is important to seed germination in oxygen-deprived condition (Anaerobic germination, AG) or withstand in germination stage oxygen deficiency (GSOD).

Strategy of rice to adapt to anoxia:

At the early vegetative stage of rice, just after germination, submergence stress imposes a barrier to its growth and development. Under this unfavorable condition tolerant rice genotypes made certain morphological and physiological changes to survive and surpass this difficulty.

Morpho-physiological traits	Anoxia tolerant rice genotypes	References
Leaf morphology	No or less reduced Leaf Area Index (LAI)	Singh et al.,2014

JUST AGRICULTURE
multidisciplinary e-Newsletter

Plant height	Quick and more elongation of shoot (Coleoptile)	Singh et al.,2014
Root growth	Higher root activity i.e., root tip viability	Bui et al.,2019
Adventitious roots	Large number of adventitious root emergence in root system and at each node	Lorbiecke et al.,1999
Total biomass	Sufficient dry mass accumulation	Singh et al.,2014
Gaseous exchange structure	Formation of aerenchyma and leaf gas film	Pradhan et al.,2017; Pedersen et al.,2009
Photosynthetic activity	Maintains higher photosynthetic activity	Panda et al., 2008
Photosynthetic pigments	Retention of higher amount of chlorophyll	Sarkar et al.,2006
Radial oxygen loss (ROL) barrier	ROL limits oxygen loss in rhizosphere	Yamauchi et al.,2018

Figure: Different tolerant genotypes of rice showing anaerobic germination

Advantages of anoxia tolerance of rice:

Direct-seeded anoxia-tolerant rice cultivars offer various advantages, making it useful to the farmer-

1. Direct seeding removes the requirement for nursery preparation and transplanting, simplifying the cultivation process,
2. By eliminating the labor-intensive transplanting stage, these cultivars reduce total production costs and reliance on human labor, which is especially useful in places with labor shortages,

JUST AGRICULTURE
multidisciplinary e-Newsletter

3. Lower input costs for labour, water, and land preparation, combined with consistent yields, result in increased net profitability for farmers,
4. Early maturity enables farmers to include more crops into the same agricultural calendar or adapt to shorter growing seasons in specific locales,
5. The shorter life cycle provides for more effective resource use, less water consumption, and decreased exposure to pests and illnesses,
6. It results lesser greenhouse gas (methene) emission,
7. In contrast to conventional techniques, removing and replanting young rice plants does not stress or harm them, guaranteeing healthier crop,
8. Direct seeding dramatically minimizes water usage during field preparation, which is crucial in water-scarce areas,
9. Reduced resource use, such as water and labor, as well as decreased greenhouse gas emissions, all contribute to sustainable farming practices.
10. High productivity ensures that farmers can offset lower expenses while maintaining or even increasing profits.

Obstacles to adaption of the direct-seeded anoxia-tolerant variety:

There are a few obstacles that act as a barrier to the advancement of direct sown anoxia-tolerant rice-

1. Direct seeding frequently necessitates a greater number of seeds per unit area than transplanted rice to ensure acceptable plant density, raising farmers' input expenses,
2. In some circumstances, crop stand establishment is unequal due to genetic sensitivity to germination and GSOD, reducing total yield potential,
3. Without the flooding associated with transplanted rice (which suppresses weeds), direct-seeded fields are prone to extensive weed development, demanding increased weed control efforts and expenses,
4. Direct-seeded rice is vulnerable to pests and diseases throughout its lifecycle, necessitating strong integrated pest management measures,
5. Direct-seeding procedures can cause deficits in key micronutrients like as zinc (Zn) and iron (Fe) due to changes in soil nutrient dynamics, affecting plant health and yield,
6. DSR may cause unequal nitrogen uptake or losses due to leaching or volatilization, resulting in imbalances that can impact crop vigor and output,

7. Stress factors such as temperatures, nutrient deficiencies, or disease susceptibility in certain cultivars can lead to sterile panicles, significantly reducing grain production,
8. Some anoxia-tolerant rice varieties may have weaker stems or are prone to lodging under heavy rains or winds, reducing harvest quality and yield.

Conclusion:

Globally more than 20% rice growing regions adopted direct seeded rice owing to anoxic germination capacity of rice. In India, the practice of direct seeding was common before green revolution until the discovery of several high-yielding transplanted rice cultivars, along with institutional support, prompted a move from DSR to transplanted rice. But it is gaining popularity again, and the Indian Council of Agricultural Research continues to endorse it at different levels. Although anoxic germination provides direct seeded rice a viable alternative to transplanted rice, a lack of encouragement and regulatory backing limits its widespread adoption. Intensive research and promotional activities are required to highlight this sustainable and climate resilient technology and leverage on semi-aquatic properties of rice.

References:

Sarkar, R. K., Reddy, J. N., Sharma, S. G., & Ismail, A. M. (2006). Physiological basis of submergence tolerance in rice and implications for crop improvement. *Current Science*, 899-906.

Panda, D., Sharma, S. G., & Sarkar, R. K. (2008). Chlorophyll fluorescence parameters, CO2 photosynthetic rate and regeneration capacity as a result of complete submergence and subsequent re-emergence in rice (Oryza sativa L.). *Aquatic Botany*, *88*(2), 127-133.

Pradhan Biswajit, P. B., Kundu Sritama, K. S., Santra Anindya, S. A., Sarkar Moushree, S. M., & Kundagrami Sabyasachi, K. S. (2017). Breeding for submergence tolerance in rice (Oryza sativa L.) and its management for flash flood in rainfed low land area: a review.

Pedersen, O., Rich, S. M., & Colmer, T. D. (2009). Surviving floods: leaf gas films improve O2 and CO2 exchange, root aeration, and growth of completely submerged rice. *The Plant Journal*, *58*(1), 147-156.

Singh, S., Mackill, D. J., & Ismail, A. M. (2014). Physiological basis of tolerance to complete submergence in rice involves genetic factors in addition to the SUB1 gene. *AoB Plants*, *6*, plu060.

Bui, L. T., Ella, E. S., Dionisio-Sese, M. L., & Ismail, A. M. (2019). Morpho-physiological changes in roots of rice seedling upon submergence. *Rice Science, 26*(3), 167-177.

Yamauchi, T., Colmer, T. D., Pedersen, O., & Nakazono, M. (2018). Regulation of root traits for internal aeration and tolerance to soil waterlogging-flooding stress. *Plant physiology*, *176*(2), 1118-1130.

Lorbiecke, R., & Sauter, M. (1999). Adventitious root growth and cell-cycle induction in deep water rice. *Plant Physiology, 119*(1), 21-30.