



Breeding Approaches for Improving Cold Tolerance Rice in High Altitude Region of Madagascar: A Review Article

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Abstract – Rice (*Oryza sativa* L.) is one of the world's most important food crops, and staple food for 65% of the global population. Among the cereals, rice is the most important source of calories for humans and forms the cheapest source of food, energy and protein; it has the second-highest worldwide production. Increasing rice production in a low income food deficit country such Madagascar is important to enhance food security.

In Madagascar, rice is the staple food for the majority of the population. The average annual consumption of rice by an individual is estimated at 118 kg/capita/year in urban areas and at 138 kg/capita/year in rural areas. Rice cultivation is practiced by about 85% of small-scale farmers; it is mainly as a food crop and as a primary source of household income for the majority of rural farmers.

Apart from the natural disaster, rice production is decreased principally because of biotic and abiotic stresses. Abiotic stress is one of the main considerations which adversely influence rice yield development and gainfulness in Madagascar. The highest part of the Madagascar high plateau region is the most densely populated (more than 80 inhabitants/Km²) area of the country. Smallholders traditionally grow irrigated or rainfed lowland rice, mostly landraces. However, rice production in this environment is highly constrained by cold weather and it is one of constraints that reduce rice yields, losses can extend from 70% to 85%. To meet the food demand in this densely populated, and also to achieve food security in this region, the present production levels need to be increased by doubling the annual production as following the main objective of the Ministry of Agriculture that envisages to double rice production at the horizon of 2018 through 2008-2018 national rice development strategy program. This objective will be possible through a combination of traditional and molecular breeding approaches.

Keywords – Breeding, Cold, Madagascar, Molecular markers, Rice.

I. INTRODUCTION

Rice (*Oryza sativa* L.) is one of the world's most important food crops, and staple food for 65% of the global population. Among the cereals, rice is the most important source of calories for humans and forms the cheapest source of food, energy and protein^[1]; it has the second-highest worldwide production^[2]. Increasing rice production in a low income food deficit country such Madagascar is important to enhance food security.

In Madagascar, rice is the staple food for the majority of the population^[3, 4, and 5]. Rice cultivation is practiced by about 85% of small-scale farmers; it is mainly as a food crop and as a primary source of household income for the majority of rural farmers^[6, 7, and 8]

Rice is grown in six zones of Madagascar: the north, northwest, and central-western regions; the central part of the Malagasy highlands; the east; and the central-eastern part, with different ecosystems under diverse environmental conditions^[5].

Apart from the natural disaster, rice production is decreased principally because of biotic and abiotic stresses. Abiotic stress is one of the main considerations which adversely influence rice yield development and gainfulness in Madagascar.

The highest part of the Madagascar high plateau region is the most densely populated (more than 80 inhabitants/km²) area of the country. Smallholders traditionally grow irrigated or rainfed lowland rice, mostly landraces^[9]. However, rice production in this environment is highly constrained by cold weather and it is one of constraints that reduce rice yields^[5] similar to the high-altitude rice-growing areas in tropical countries^[10, 11, 12, 13, 14], cold stress causes an important factor affecting rice production in such areas^[15], losses can extend from 70% to 85%^[16] and it is a common problem in rice cultivation and a crucial factor in global production^[17].

To meet the food demand in this densely populated, highlands region, and also to achieve food security in this region, the present production levels need to be increased by doubling the annual production as following the main objective of the Ministry of Agriculture that envisages to double rice production at the horizon of 2018 through the 2008-2018 national rice development strategy program and as part objective of the Coalition for African Rice Development (CARD)^[18]; this objective will be possible through combination of traditional and molecular breeding approaches.

Rice cold tolerance breeding was first reported by Rasolofo et al^[19]; rice yields are low in high altitude regions due to the cold effect at seedling and reproductive stage^[16].

The High Plateau is characterized by the alternation of a hot, rainy season from November to April and a cold dry season from May to October. Altitude has a strong effect on mean temperatures, which decrease by 0.6°C every 100 m. Mean temperatures at 1650 m in Antsirabe, the main town of the highland region range from 17.9°C in October, at the beginning of the rice-sowing period, to close to 20°C during the reproductive stage. Minimum temperatures can fall below 10°C during early vegetative stage and are below 15°C during the reproductive stage and grain filling. The night-day thermal amplitude is high (10–12 degrees) during the whole rice-growing season. Low temperatures slow rice growth in almost all stages:



panicle initiation is delayed and grain-filling and maturation stages are lengthened^[9].

Plant breeding in its conventional or traditional approach based on the phenotypic selection routine. Phenotyping routine is visually assessed by measurable traits, and the best-performing plants are chosen within populations by phenotype details^[20]. It is the comprehensive assessment of complex plant traits such as growth, development, tolerance, resistance, architecture, physiology, ecology, yield, and the basic measurement of individual quantitative parameters that form the basis for more complex traits^[21, 22]. Seedling vigor, seedling leaf growth scale, seedling survival rate then yield-related traits as the percentage of spikelet fertility, 1000 grain weight (g), and yield (kg ha⁻¹) are the direct measurement parameters to assess for cold tolerance rice genotype respectively at seedling and reproductive stage^[23,24,25].

To improve the yield under cold stress condition, countless breeding programs have been initiated. Madagascar's cold-tolerant rice breeding program started with a vast collection of irrigated rice germplasm taken from local and international sources^[26], but the success rate of conventional breeding is not ample to cover the needs of the population, the country still has imported about 200,000 tons of rice in the first three months of 2015^[27].

Improving the efficiency of breeding by indirect selection at the genotyping level^[28] is an approach to change this situation quickly. A combination of traditional breeding with the assistance of DNA markers from Molecular Assisted Selection MAS could facilitate selection; individual genotypes with target gene in a segregation population can be identified faster and efficiently^[29], the utilization of molecular markers put incredible significance for screening anxiety tolerant attributes in rice^[30].

DNA marker also called molecular markers are a small region of DNA sequence showing polymorphism (base deletion, insertion and substitution) between different individuals^[31]. Marker-assisted selection (MAS) refers to such a breeding procedure in which DNA marker detection and selection are integrated into a traditional breeding program.

II. CONCLUSION

To feed the high density populated in the high altitude region of Madagascar, we need to solve the cold stress effect in rice and this is the principal challenge for Plant breeder. Conventional breeding is still a widely used strategy for developing crop varieties with a higher yield potential. The integration of molecular marker applications with conventional plant breeding practices has created the foundation for molecular plant breeding and will certainly accelerate rice improvement programs across region of Madagascar including the high altitude area. Molecular Assisted selection (MAS) has become an integral component of rice improvement not only for cold, but also for various abiotic stresses. A large number of genes for

various traits have been tagged with molecular markers to apply MAS for trait improvement.

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