Weathering the cold

Africa develops rice that can thrive in the region's cooler zones

by **Negussie Zenna, Ashura Luzi-Kihupi, Baboucarr Manneh, Rabeson Raymond, Elie Rene Gasore,** and **Karim Traore**

TANZANIAN FARMERS bend their backs transplanting rice beneath snow-capped Mt. Kilimanjaro, the highest peak on the African continent.

KILIMANJARO AGRICULTURAL TRAINING CENTRE

In sub-Saharan Africa, rice is one of the most significant crops—as both a food and cash crop. This is evident from the recent civil unrest that broke out in many African countries because of rice shortages. As the African population is expected to hit one billion soon, the region is worried that its rice production will fall short of the growing demand. Africa's terrain poses many challenges to farmers, thereby limiting the continent's full potential to grow rice and attain food self-sufficiency.

The most striking geological feature in Africa is undoubtedly the East African rift system. The main section of the valley starts from the Red Sea, crosses through Ethiopia, Kenya, Tanzania, and Malawi, and plunges into the lower Zambezi River valley in Mozambique. The rift has formed Africa's mountainous regions, including Mount Kilimanjaro in Tanzania, which soars 5,796 meters above sea level. It is permanently capped with snow even though it is near the equator. This unique topography gives sub-Saharan Africa the most diverse and complex agroecological zones for rice production of any region in the world.

If cold-tolerant varieties of rice can be improved for farmers to maximize planting and boost rice production in the highlands of East Africa and the cold-prone areas of the Sahel region, Africa will be well on its way toward alleviating poverty and ensuring food security for its many people.

Low temperature retards the rice plant's growth. This is a common problem among farmers who sow rice during cool seasons, and among those who grow rice at high altitudes and in areas that have a cold irrigation-water supply. Damage depends on the prevalent air or water temperature, cropping pattern, growth stages of the crop, and variety. Damage can be observed at any growth stage, and it often leads to crop failure. Cold conditions inhibit the seed's metabolic process; hence, seed germination fails. Other outcomes are slow seedling growth, stunting, discoloration, panicle degeneration, sterility, and irregular maturity. Given such wide-ranging effects of low temperature on rice and the serious impact on productivity, several African rice-growing countries have invested their resources in developing cold-tolerant rice varieties. Among these countries are Ethiopia, Madagascar, Tanzania, Rwanda, Mali, and Senegal.

Ethiopia

Although rice production was just recently introduced in this country, paddy area has already surpassed 150,000 hectares—and this has been achieved in mid- and low-altitude areas only. The vast highland plateaus located at about 2,000 meters above sea level, in spite of their high potential for rice production, could not be used because of the unavailability of cold-tolerant varieties. A few varieties are grown in the mid-highlands (as high as 1,800 meters) such as X-jigna and WAB 189. Recently, through support from the Sasakawa Africa Association, germplasm collections from the International Network for Genetic Evaluation of Rice (INGER) at the International Rice Research Institute (IRRI) and other sources were introduced to adapt or develop cold-tolerant varieties suitable for higher altitudes.

Madagascar

Rice is the staple food in the densely populated high plateau of Madagascar. Farmers traditionally grow irrigated rice or rainfed lowland rice in inland valleys and on hillsides. Magnificent rice terraces can be seen at 1,900 meters. Mean temperatures at 1,500 meters vary from 17 °C in October, the rice-sowing period, to 20 °C during the reproductive stage. Minimum temperatures can fall below 10 °C during early vegetative stage and are below 14 °C during reproductive stage and grain filling. Low-temperature damage is worse with a temperature drop during the seedling or reproductive stage.

Madagascar's cold-tolerant rice breeding program started with a vast collection of irrigated rice germplasm taken from local and international sources. Those belonging to the *Latsika* family had the best performance in sterility rate, grain yield, and tolerance of sheath blight. The *Latsika* family belongs to the temperate japonica group. Varieties of this family are traditionally cultivated in lowland ecosystems with altitudes above 1,800 meters. Although the released varieties have shown tolerance of cold, the extended growth period, from October to April/May (because of the cold temperature), made double cropping difficult. Hence, increasing productivity has been rendered impossible.

Tanzania

Tanzania is the second-largest rice producer in East Africa. Quite accustomed to eating rice, Tanzanians have developed a unique taste for this staple cereal. Most prefer aromatic rice that becomes long and fluffy when cooked. Varieties that have these qualities often have low yield and thus command higher prices among producers. One possible way to increase the productivity of these preferred varieties is through double cropping. However, this could not be realized in the southern highlands region because farmers use the cold water from the mountains for irrigation during the cool season.

Rwanda

Rwanda has extensive irrigation schemes for rice cultivation in the highlands. Rice production can be carried out in areas such as Ruhengeri, which is at about 2,000 meters. During the cold season, the temperature in this area can go as low as 10 °C. A few cold-tolerant japonica varieties have been grown in the country since the 1970s, such as Zong eng, Yunyine, and Yun keng. However, since consumers prefer long-grain indica rice, farmers grow japonica types only during the cold season for their own consumption. Thus, breeding cold-tolerant indica rice is the major objective in the country.

The Sahel region (Mali and Senegal)

Rice consumption is very high in West Africa. For instance, Mali and Senegal consume 60 and 70 kilograms per capita per annum, respectively. Total crop failure because of low temperatures in the Sahel region has been a major problem. Planting rice seeds between mid-September and mid-November was associated with near-total spikelet sterility in Sahel countries. Higher variation in the crop cycle was observed in the coastal west and extreme north of the Sahel due to cold stress. Short-duration varieties were introduced earlier; however, they were mostly japonica types (I Kong Pao from Taiwan, Tatsumi Mochi from Japan, and AIWU and China-998 from China). None of these varieties are now widely grown because consumers prefer the slender indica types. Finding varieties that can thrive during the cold dry season has therefore become crucial in order to increase rice productivity in the Sahel region.

Currently, IRRI and the Africa Rice Center (AfricaRice) have joined efforts to develop improved cold-tolerant rice varieties under the Stress-Tolerant Rice for Poor Farmers in Africa and South Asia (STRASA)-Cold project. This collaboration involves six countries in Africa: Mali and Senegal in the west and Madagascar, Tanzania, Rwanda, and Ethiopia in the east. On-site activities are carried out in AfricaRice substations—in Senegal for West Africa and in Tanzania for East Africa.

Moreover, under the STRASA-Cold project, varieties adapted to low-temperature conditions are assembled from INGER, along with prebreeding materials from the International Cold-Tolerant Nursery and Temperate Rice Research Consortium. The germplasm is evaluated under actual field conditions, in collaboration with national agricultural research and extension systems. The field screening activity has a participatory varietal selection component, in which farmers get involved in the varietal selection process; and a seed production component, in which farmers are given access to quality seed. Plant breeders use conventional and molecular breeding approaches to transfer the cold-tolerance trait to local mega-varieties.

Over the past years, different researchers have identified several genetic markers linked with genes that possess cold-tolerance traits. Hence, marker-assisted breeding has become an important component of the breeding program. This approach can facilitate the rapid generation of improved cold-tolerant varieties with acceptable grain quality for Africa. These varieties, aside from increasing productivity and ensuring food security, would also help alleviate poverty in the region, as they meet the needs of resource-poor farmers.

NEGUSSIE ZENNA

DR. NEGUSSIE Zenna, postdoctoral fellow, and Mr. Martin Ndomondo, research technician, of AfricaRice develop cold-tolerant breeding lines in Morogoro, Tanzania.

KARIM TRAORE

AfricaRice scientists and national partners visit a cold-tolerant rice line in Fanaye, Saint Louis, Senegal.

Dr. Zenna is a postdoctoral fellow and Dr. Kihupi is a regional liaison scientist at AfricaRice, Dar es Salaam, Tanzania. Dr. Manneh is a molecular biologist and coordinator of the Abiotic Stresses Project and Dr. Traore is a rice breeder at AfricaRice, Saint Louis, Senegal. Dr. Raymond is a scientist and head of the rice program at the National Centre for Applied Research on Rural Development (FOFIFA), Madagascar. Mr. Gasore is the director of the Rice Research Programme at ISAR (Institut des Sciences Agronomiques du Rwanda).