Critical Roles of the Puerto Rico Winter Nursery in the Southern US Rice Breeding Programs

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ABSTRACT

Rice is one of the important crops in the Mississippi delta and coastal Louisiana and Texas. About three quarters of US rice is produced in the Mid-South including Arkansas, Louisiana, Mississippi, Missouri, and Texas. Rice breeding programs in these states as well as USDA-ARS Dale Bumpers National Rice Research Center rely on the winter nursery at Lajas, Puerto Rico for generation advancement, seed purification and increase, germplasm propagation and rejuvenation of the USDA world collection.

Established in 1970 by Louisiana State University in a cooperative agreement with the University of Puerto Rico, the nursery is located at the University of Puerto Rico's Agricultural Experiment Station at Lajas and managed by the station personnel. Since then, USDA-ARS and public breeding programs at University of Arkansas, Mississippi State University, Texas A&M University have joined the cooperative agreement, which makes the winter nursery more cost effective and accessible. Currently, there are about 70 acres of land dedicated to the rice nursery and accessible to the participating institutions and other companies. Significant improvements on land leveling, irrigation and drainage, small machineries of planting, harvesting, and spraying, as well as drying facilities allow timely planting, harvesting, and processing of the breeding materials and small seed increases. Under the tropical climate, one to two extra generations of rice can be grown and harvested, which results a 1-3 years' reduction in the variety development cycle. Almost all the rice cultivars released in the Southern US since early 1980s went through at least one generation at the winter nursery. With the recent launch of the public hybrid rice breeding program, Puerto Rico winter nursery will continue to play an important role in the development of rice cultivars and hybrids in the Southern US.

RATIONELES

- Tropical weather with the average high of 89°F, low 67°F, and rainfall 48 inches per year. Rice can be grown year-around.
- Volcanic heavy clay soil and ample irrigation water near Lajas valley.
- As a US territory, Puerto Rico is treated as a domestic destination for customs, immigration, and transportation, therefore it is very convenient for conducting the winter nursery.
- Short daylength and warm temperature dramatically shortens the growing season which enables to grow two consecutive generations from August to April.

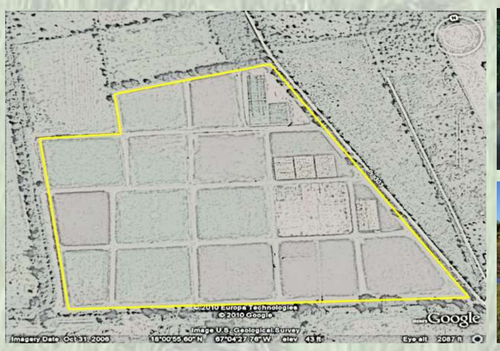

Figure 1. Map of the main area of the nursery (within the yellow lines) by Google. The field is flat and sub-divided into 4-5 acre parcels. Irrigation risers were installed for each parcel. All fields are on a 2 year rotation of planting and farrow, and the farrow field is plowed and disked frequently to prevent weeds and volunteer rice.

NURSERIES

- Due to the tight time window, rice seeds (primarily F_2 and F_3) have to be processed immediately after harvest, loaded, and packaged for the rush shipment to Puerto Rico for early planting. Typical planting date for single generation advancement or seed increase is in the month of November, while in order to grow two consecutive generations, rice has to be planted before the middle of August.
- Field managements are carried out by the University of Puerto Rico (UPR) collaborators, which include irrigation, weed control, herbicide and fertilize application, staking, and netting for bird control.
- Selection and harvest normally occurs from March to May by the breeders and/or their crew traveling from the states and assisted by UPR personals.
- However for turnaround nursery, the first generation has to be selected/harvested in early December. The harvested seeds will be processed on-site and packaged for the immediate planting.

- A modified single seed descent methodology was applied for all generation advancement progenies, however, the pedigree selection has been routinely carried out by several breeding programs especially those in Louisiana. The reasonably uniform F_3 or F_4 panicle rows were bulked for preliminary yield trials in the continental US.

Figure 2. Rice seeds packaged in magazines/trays and planted by a Hege row planter (up left). Herbicides were applied by a small rig mounted on a four wheeler (up middle). Nets were provided after heading for protection against birds (up right). Selection was made for further advancement (low left), bulk-harvest (low middle) for preliminary yield trials, and seeds were cleaned (low right) and dried for shipping back to the states.

CRITICAL ROLES AND FUTURE PROSPECTIVES

- Since the inception of the winter nursery in 1970, almost all of the 70 plus public new releases from Southern US have at least one generation been grown in Puerto Rico.
- The pedigree selection in the winter nursery, which is similar to the shuttle breeding in wheat (Borlaug, 1968), is responsible for the development of a number of new cultivars such as Jazzman-2 (Sha et al. 2013) and has proven to be effective. Therefore, it extends the selection process from continental US to Puerto Rico.
- As proven in wheat, the shuttle breeding in two contrast environments resulted in photoperiod insensitive cultivars, which leads to the wider adaptation. This may explain the phenomena that the semidwarf rice cultivars released by Louisiana dominated the Mid-South rice growing region in last two decades.
- The selection in the Puerto Rico winter nursery may also contribute to the most significant breeding achievement in Mid-South rice growing region in last 30 years by shortening the growing duration meanwhile retaining or further improving the yield potential. For example, the current predominant semidwarf cultivar CL151 matures about 10 days earlier than Lemont which was released and widely grown in 1980s and 1990s (Blanche et al. 2010; Bollich et al. 1985; McKenzie et al. 2014).
- Seed purification and increase is another important function of the winter nursery and is actively pursued by breeding programs in Louisiana and Mississippi, as well as the private seed company Horizon Ag. By growing the breeder head rows off-season in the Puerto Rico nursery, rice seeds of new cultivars become readily available at least one year earlier.
- The short daylength combined with cooler temperature during the dry season (November to April) in Puerto Rico provides the ideal condition for the breeding and propagation of environmental sensitive male sterility used in the recently launched public hybrid breeding programs.

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