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Potential Development of Petroleum-Resistant Coastal Plants

The current major crude oil spill in the Gulf of Mexico poses a significant threat to coastal marshes in the coastal regions. While rapid deterioration of the physical health of coastal vegetation and marine life is the indication of direct adverse effects of the spill, the ecosystem function as a buffer supporting the economic, culture and livelihood of local communities who depend on this ecosystem is also diminished. The oil spill also affects the wildlife that use the Gulf Coast marshes as their sanctuary, resting and nesting sites and nurseries. Petroleum-resistant coastal plants are, therefore, needed to help with recovery of coastal marshes from the catastrophic effects of the spill.

Petroleum is a complex mixture of more than 6,000 compounds that can be grouped into the alkanens, aromatics, resins and asphaltenes. Crude oil contamination poses serious environmental and human health problems. The aromatics, especially polycyclic compounds, are of major concern because of toxicity, mutagenicity and carcinogenicity. Bioremediation using plants and microorganisms to remove and detoxify these contaminants can be part of other cleaning methods, such as washing, removal and burning. For successful bioremediation, both plants and microorganisms have to survive and grow in crude oil-contaminated soil. Petroleum-resistant coastal plants can be used as a bioremediation tool.

Field studies from previous petroleum-contaminated soils in the other places have identified plants that survive. Natural coastal marsh plant populations along the Gulf Coast regions have shown considerable genetic diversity. It has been established in the literature that natural genetic diversity is a critical component of long-term survival of the populations and their adaptation to constantly changing growing conditions, competition and predation. Under strong selection pressure, such as the current massive crude oil spill, the levels of genetic diversity among natural populations of coastal marsh plants will determine their survival. The likelihood of finding native plants resistant to petroleum contaminant is a direct function of their genetic diversity levels. The higher the diversity levels, the better the chance in recovering plants resistant to petroleum.

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Special Dates of Interest:

Arkansas Rice Research & Extension Field Day
Stuttgart, AR
August 11, 2010

California Rice Field Day - Biggs, CA
August 25, 2010

Missouri Rice Council Field Day - Glennonville, MO
August 26, 2010

An additional approach for developing petroleum-tolerant plants is by inducing genetic changes to allow plants to be resistant to crude oil contaminants. If the natural population cannot provide a genetic basis to adapt to such sudden changes, it will be necessary to generate new genetic configurations to allow plants to overcome the harsh environment that would otherwise be lethal to them. In recent years, laboratory-induced genetic changes have been part of routine protocols to generate new types of plants capable of tolerating conditions that otherwise would be toxic. An example of induced mutational breeding is herbicide-resistant Clearfield rice developed at the Rice Research Station. The Rice Station has the capability to conduct similar experiments to produce petroleum-resistant marsh plants. Induced mutation breeding techniques include the use of mutagens, radiation and *in vitro* selection using protoplasts to change genetic configurations to allow plants to tolerate crude oil contamination. Under appropriate laboratory conditions, millions of cells can be produced weekly and subjected to induced mutation in an attempt to generate petroleum-resistant plants. Figure 1 shows a series of *in vitro* selections via a protoplast system. Instead of thousands of acres to grow millions of plants, this approach reduces the task to laboratory-size Petri dishes.

Figure 1.

Protoplast culture of smooth cordgrass (*Spartina alterniflora*) that can be used for *in vitro* selection to develop petroleum-resistant plants.

Mortality of marsh vegetation as a result of the crude oil spill will trigger rapid conversion of currently healthy marshes into open water. This rapid conversion can only be averted through rapid re-planting of the affected areas using petroleum-resistant plants. In designing genetic changes that give rise to petroleum-resistant marsh plants, it is also important to investigate their phyto-remediation capabilities. The vigorous biomass of native coastal plants can provide significant binding sites for harmful elements, allowing toxic heavy metals to be sequestered in wetland sediments in non-bioavailable forms. Because of numerous activities associated with fossil fuel refinement and petrochemical industries, southwest Louisiana is susceptible to heavy metal contamination related to spillage and accidents. In addition, the ship canals connecting refinery sites are continually dredged, and this can bring previously dormant or settled contaminated soils to the surface, creating potential heavy metal toxicity. This can affect the productive commercial and recreational fishing industries. In addition, to help rapid revegetation of marshes following the crude oil spill, phyto-remediation of heavy metal pollutants through the use of petroleum-resistant plants will help overcome environmental, agricultural and human health problems.

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Redefining Optimum Seeding Rates in Clearfield Varieties

During the 20th century, the only method to suppress red rice in commercial rice production was by water seeding. Most rice producers were aware that if the fields could be kept flooded during the season, most of the red rice seed in the soil would not have the opportunity to germinate. Aerial application of pre-germinated rice seed was not only convenient, it was the best red rice control method available to rice farmers at the time.

After the release of Clearfield rice varieties for commercial rice production in 2003, water seeding was no longer the only management practice that could be used for red rice control. Red rice could now be controlled with the use of imidazolinone (Clearfield) herbicides, and a shift toward more drill-seeded acres began to occur.

With each passing season, rice producers were becoming more comfortable using a grain drill to plant rice and using the Clearfield herbicide program. Today, drill seeding is the predominant seeding method of rice in Louisiana. This is quite different than it was less than 10 years ago when water seeding was by far the most popular. This is yet another example of how technology created at the LSU AgCenter Rice Research Station has changed the way rice is produced, not only in Louisiana but in the entire Mid-South.

The Clearfield technology has done wonders for weed control in rice production. This technology comes with a price, though, and all rice farmers are aware of the cost difference between rice seed with and without the Clearfield trait. In fact, as producers have gotten more comfortable with drill seeding and using the Clearfield herbicide program over the past decade, they have used lower seeding rates to save money – even lower than the official LSU AgCenter recommendations.

Currently, we recommend 60 to 90 pounds per acre for drill-seeded rice, with a target plant population of 10 to 15 plants per square foot. This current trend of using lower-than-recommended seeding rates has been used successfully by many farmers. However, it also raises many questions and several red flags. We have to remember that the success of such a system is contingent on several factors, including having a good clean seedbed, a good drill that places the seed at a constant depth and provides excellent soil to seed contact, the ability to maintain good soil moisture, optimum fertility, optimum soil/air temperatures and, most importantly, excellent weed control. The bottom line is that everything must be managed closely for a low seeding rate system to work. Nonetheless, past successes by some producers have caused us to reevaluate our current drill-seeding rate recommendations in a Clearfield system.

This year, we have initiated several trials focused on determining the optimum seeding rates and target plant populations for almost all of the commercially available Clearfield rice varieties. Separate trials are being used to evaluate CL111, CL131, CL151, CL142, CL181 and CL261. Treatments include nine seeding rates (5, 10, 15, 20, 25, 30, 35, 40 and 45 seed per square foot) or approximately 10 to 110 pounds of seed per acre, depending on variety and two tillage systems – conventional tillage and fall-stale seedbed. We plan to evaluate the change in plant characteristics (plant height and lodging potential) and yield components (yield, number of panicles, number of filled grains per panicle, and grain weight per panicle) corresponding with the change in plant population. We also hope to determine the optimum plant population needed to maximize the ratoon crop yields, which is most likely higher than the optimum plant population in the main crop.

Results of the first year of these trials will be shared at the upcoming rice production meetings this winter. Until research can consistently prove otherwise, our current drill-seeding recommendations for Clearfield rice varieties will continue to be 60 to 90 pounds of seed per acre, with a target plant population of 10 to 15 seed per square foot.

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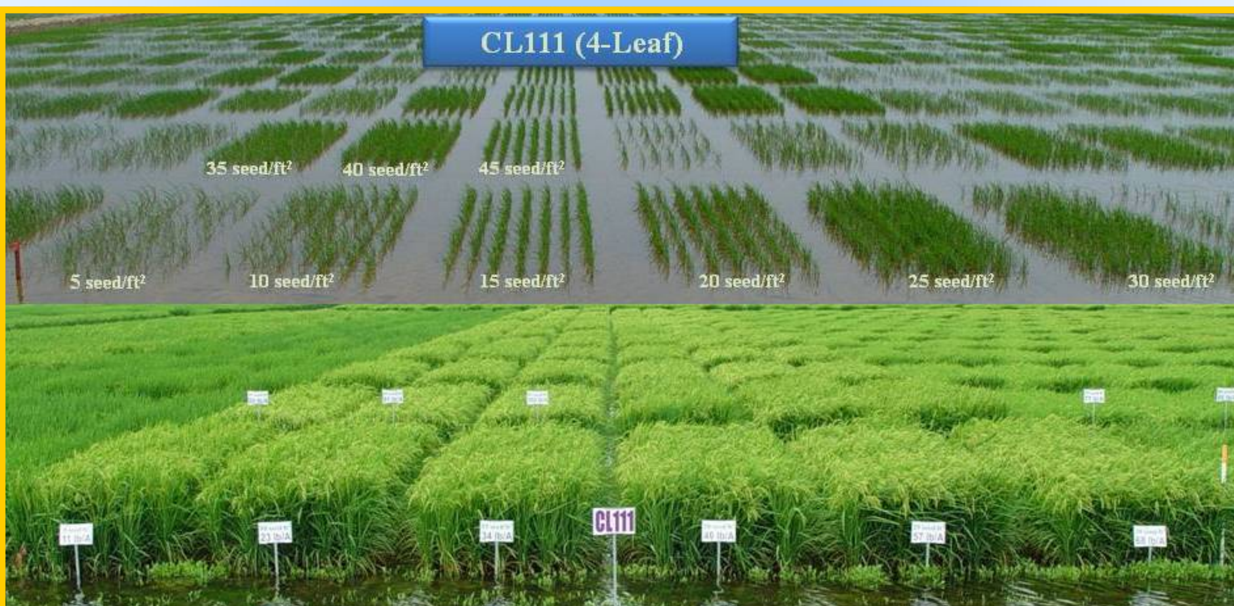

Potential New Rice Varieties for 2011

The LSU AgCenter Rice Research Station has three advanced experimental rice lines being considered for potential release in 2011:

LA2149 is a semidwarf, early-maturing, Jasmine-type aromatic, long-grain experimental rice line with good grain and milling yields and excellent grain quality. It was developed by using the pedigree selection technique from a 2003 cross between an unreleased Louisiana conventional long-grain line 0302195 and an unreleased Louisiana Jasmine-type aromatic rice line 0302125, which has the pedigree of Jasmine 85/Della//Leah/Della. The average yield of LA2149 was 6,892, which is slightly lower than 7,005 pounds per acre of Jazzman. However, the average whole grain and total milling yields for LA2149 were 63.2 percent and 70.2 percent, respectively, which are higher than that of Jazzman. On average, LA2149 is 3 inches shorter than Jazzman and matures four days earlier than Jazzman. LA2149 has typical Jasmine cooking qualities with low amylose content, low gelatinization temperature and very strong aroma. LA2149 is susceptible to sheath blight, bacterial panicle blight and straighthead disorder but moderately resistant to blast. Like Jazzman, LA2149 has glabrous leaves, lemma, palea and no dormancy.

LA2162 is an early-maturing, semidwarf medium-grain line with excellent yield potential, very good milling yields and grain quality, and a very bold grain. It was developed from an ongoing recurrent selection program using the varieties Bengal, Mercury and Rico 1. The specific pedigree for this line is Bengal//Mercury/Rico 1/3/Mercury/Rico 1// Bengal. The average yield of LA2162 was 8,100 pounds per acre compared with 8,086 and 7,283 for Jupiter and Neptune, respectively. The average whole grain and total milling yields for LA2162 were 68.7 percent and 72.3 percent; for Jupiter, they were 68.2 percent and 71.3 percent; and for Neptune, they were 68.8 percent and 72.2 percent, respectively, in the same trials. In addition, LA2162 has shown very little chalk, as well as a very bold grain that approaches the size of typical Calrose-type varieties grown in California. While LA2162 averages 1 inch taller in plant height than Jupiter, limited testing has indicated that it will have better resistance to lodging. LA2162 has typical southern medium-grain cooking qualities. LA2162 appears to be moderately susceptible to sheath blight, blast, bacterial panicle blight and straighthead disorder.

LA2051 is an early-maturing, long-grain, semidwarf Clearfield rice line with very good grain yield and quality. It was developed from the cross Tacauri/3/Cypress//L202/Tebonnet/4/CL161. Tacauri is a high quality long-grain variety from Uruguay, while L202 is a long-grain variety developed in California, and Tebonnet is a long-grain from Arkansas. The average yield of LA2051 was 7,881 pounds per acre in multi-location testing in 2009, while the yields for CL151 and CL111 were 8,501 and 7,493 pounds per acre in the same trials, respectively. The average whole-grain and total milling yields for LA2051 were 66.7 percent and 71.8 percent; for CL151, they were 65.5 percent and 72.2 percent; and for CL111, they were 66.5 percent and 71.9 percent, respectively. All three of these varieties average about 36 inches in plant height at maturity, but limited testing has shown that LA2051 appears to have better lodging resistance than CL151 and CL111. LA2051 will be about two to three days later in maturity than CL151. LA2051 appears to have higher levels of resistance to blast than CL151 and appears to be susceptible to sheath blight and moderately susceptible to bacterial panicle blight and straighthead disorder.

All three of these lines are being increased in potential foundation seed production fields by Mr. Larry White on the Rice Research Station this summer. Decisions on potential releases will be made this winter after analyses of additional data generated in multi-location testing in 2010.

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Potential for Development of Salt-and Drought-Tolerant Rice Lines

Salinity and drought are two abiotic stresses that pose major challenges for sustainable rice production in rice-growing regions around the world. In southwest Louisiana, a significant amount of rice acreage was lost to the salt water intrusion caused by the severe drought in 1999, as well as to the salt water inundation in 2005 from Hurricane Rita and in 2008 from hurricanes Ike and Gustav. Drought spells have become more frequent and severe, leading to irregular and insufficient irrigation of the crop and over-consumption of groundwater resources in certain areas of the southern rice-growing region. Because the frequency and severity of those abiotic constraints are predicted to increase, there is the urgent need to develop salt- and drought-tolerant rice varieties.

The rice plant is moderately sensitive to salt stress. If irrigation water has salinity over 1,280 parts per million, it can hinder rice growth and yield, particularly at the seedling and booting stages. Several physiological mechanisms can impart salt tolerance in plants. These include salt exclusion, compartmentation of toxic salts in older and structural tissues, higher tissue tolerance by sequestering salt into vacuoles, responsive stomata, an efficient antioxidant system, and vigorous growth habits to dilute salt concentration in tissues.

Drought tolerance is closely associated with osmotic adjustment, leaf rolling, maintenance of leaf water potential, water conductance, photosynthetic capacity and root characteristics. Like yield and milling quality, both salt and drought tolerance are complex traits controlled by the interaction of many genes. Because of polygenic inheritance, breeding progress achieved by conventional methods is slow. Because of advances in molecular genetics and genomics technology, it is now possible to discover, track and stack these genes in rice varieties for improved crop performance under stress environments.

To develop salt- and drought-tolerant rice, a thorough understanding of the mechanisms underlining such stress tolerance at the molecular level and the identification of favorable alleles from tolerant germplasm for introgression into commercial rice varieties is needed. The recently finished and publicly available whole rice genome sequence provides a new tool for such a task. At the LSU AgCenter, Dr. Prasanta Subudhi with the School of Plant, Soil & Environmental Sciences has recently initiated research on both salt- and drought-tolerant rice. By working with scientists at the Rice Research Station, as well as at other institutes including Texas A&M University, the University of Arizona and the International Rice Research Institute (IRRI) of the Philippines, he will combine classical breeding with modern genomics and proteomics tools to enhance both salt and drought tolerance and to dissect the genetic network associated with the complex abiotic stress tolerance mechanisms in rice.

For molecular mapping and breeding purposes, various populations will be developed by crossing the introduced salt-tolerant varieties (Pokkali and Nonabokra) and drought-tolerant varieties (Nagina 22, Dular and Moroberekan) with adapted commercial varieties. Individual quantitative trait loci (QTL) will be studied as single Mendelian factors for variation in salt and drought tolerance. Candidate genes corresponding to the major QTL regions will be identified and cloned for a thorough understanding of the associated molecular and physiological mechanisms. With the identification of QTLs with a large and consistent effect on grain yield under drought and salinity, commercial varieties and advanced lines of the southern United States will be improved through QTL introgression and pyramiding. Because only the natural genetic variations are exploited by using conventional breeding involving marker-assisted selection, the improved rice varieties or lines will not be considered as genetically modified organisms (GMOs).

Performance of rice genotypes after two weeks of exposure to 150 mM NaCl stress.

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Chefs Tour Rice Field Day

One of the companies marketing Jazzman rice brought a group of Louisiana chefs to the field day at the Rice Research Station. The objective of the tour was to familiarize the chefs with the rice growing process. To the left chefs pose with rice breeders Xueyan Sha and Steve Linscombe. To the right, chefs Jared Rising and Matthew Beaudin, both of L'auberge Casino in Lake Charles, examine a rice plant.

The rice in the above photo is currently growing on the LSU AgCenter Rice Research Station. The purple rice line is a marker that was developed by Dr. Kenneth Gravois (AgCenter Sugarcane Specialist) while he was working as a rice breeder with the University of Arkansas. The gold leaf line is an induced mutant that was selected from an indica population that Dr. Neil Rutger developed. This line was obtained from the *Oryza* (GSOR) Collection at Dale Bumpers National Rice Research Center in Stuttgart, Arkansas.

Pest of the Quarter Rice Sheath Rot

This disease is caused by the fungal pathogen *Sarocladium oryzae*. Symptoms are most severe on the uppermost leaf sheaths that enclose the young panicle during the boot stage. Lesions are oblong or irregular oval spots with gray or light brown centers and a dark reddish-brown, diffuse margin (Photo 1), or the lesions may form an irregular target pattern. In Louisiana the lesion is usually expressed as a reddish-brown to purple-brown discoloration of the flag leaf sheath. Early or severe infections affect the panicle so that it only partially emerges. The unemerged portion of the panicle rots, turning florets dark brown. Grains from damaged panicles are discolored reddish-brown to dark brown and may not fill (Photo 2). A powdery white growth consisting of spores and hyphae of the pathogen may be observed on the inside of affected sheaths. Insect or mite damage to the boot or leaf sheaths increases the damage from this disease. This disease affects most rice varieties. The disease is usually minor, affecting scattered tillers in a field. Occasionally, larger areas of a field may have significant damage. Control measures are not recommended. Fungicidal sprays used in a general disease management program reduce damage but have little activity against this disease. Recent studies show that the bacterial panicle blight pathogen and Cercospora fungus often cause similar sheath rot symptoms on rice.

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PHOTO 1

PHOTO 2

2010 FIELD DAY HIGHLIGHTS

Photos by Bruce Schultz

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RICE RESEARCH STATION 1909-2009

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Focus

'Every office should have a Darlene'

Darlene Regan started working at the Rice Research Station in 1984. She began as a clerk and then worked in the field with Dr. Richard Dunand for three months before being transferred back to the clerk job.

She learned of the job opening while finishing her studies at the Vocational Technical School in Crowley. Regan said she considers herself fortunate to get the job.

"It was the best thing that could have happened," she said.

She was born in Basile and lived for a few years in Iota before her father began traveling in southwest Louisiana, east Texas and even Maryland in his cable television job. She graduated from high school in Sulphur.

When she started working at the station, Duke Faulkner was director at the time. He was followed by Joe Musick and then the current director, Steve Linscombe.

The station's office was so small at the time that she was assigned work space in the library. When she began her career, it was the same time that the typewriter was being replaced with the IBM Display Writer.

As administrative coordinator, Regan keeps track of payroll, inventory and human resource reports, all on computer, and she can't envision how her job could be done on a typewriter.

She said she enjoys her work at the station because of her co-workers. "The people are wonderful and it's very family oriented. I just can't imagine having to get up every day and go to work and not like my job. "

Darlene is married to Joey, and they have five children and two grandchildren. She said when she's not at work, she's got plenty to keep her busy, especially with an 11-year-old daughter at home.

She is active in the Lutheran Church in Iota where she teaches Sunday school, and she volunteers at the Christian Care Center in Iota. She also started canning vegetables from her garden and making jelly.

Linscombe said Regan is a model employee. "She is dedicated to her work and maintains an excellent relationship with her fellow employees," he said. "Every office should have a Darlene."

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