Caribbean Basin Administrative Group

TROPICAL AND SUBTROPICAL AGRICULTURE

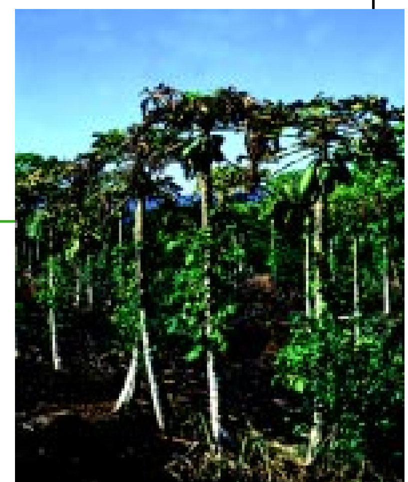
Research notes

summer 99

Pacific Basin Administrative Group

Rickettsia Discovered in Diseased Papaya Apparently Causes the Disease and Provides Clue to Plant Evolution

Michael J. Davis, Zhentu Ying, Bryan R. Brunner, Alberto Pantoja and Feiko H. Ferwerda



Papaya bunchy top.

A close relative of the human rickettsial pathogens causing such diseases as typhus and spotted fever has been found associated with papaya bunchy top disease, which greatly limits papaya production in the Caribbean area. It is the first rickettsia found to parasitize plants, and the discovery has important implication not only to respect to disease diagnosis and management, but also with regard to the theory that plant organelles have evolved from primitive bacteria.

Papaya is native to the American tropics but is now cultivated widely troughout tropical and subtropical areas of the world for both local consumption and export of fruit and, to a lesser extent, for production of the enzyme papain. Papaya production in the American tropics and subtropics is severely limited by several diseases, among which papaya bunchy top is one of the most economically important. Production of papaya requires relatively low maintenance costs with fewer needs for pesticides

➥ page 4

The Challenges of Developing a Natural Enemy Augmentation Program for Pink Pineapple Mealybug Management

Marshall W. Johnson and Raju R. Pandey

Efforts to develop alternatives to a chemical-based management system for pink pineapple mealybug control are focused on the potential use of augmentative mass releases of one of the mealybug's natural enemies. The first challenge in the augmentative program is the ability to rear millions of individuals of the required natural enemy.

Pineapple crops worldwide are plagued by tiny insects called mealybugs which feed on pineapple plant sap. Most people would not recognize mealybugs as insects. Mealybugs impact the size of pineapple fruit by withdrawing plant nutrients. A sweet liquid called "honeydew" is produced during mealybug

➥ page 8

Improved Monitoring Systems for Two Important Weevil Pests of Ornamental Palms in Florida

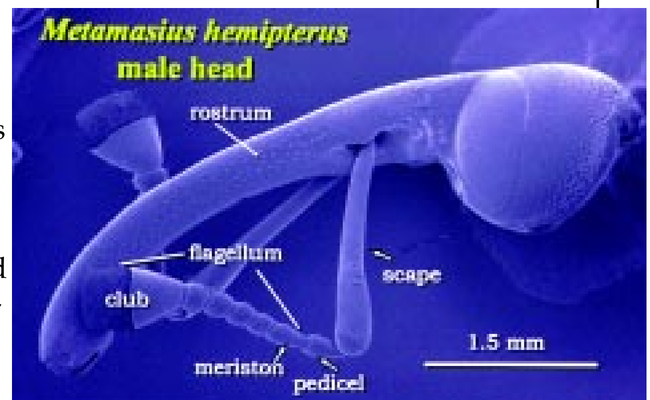
Robin M. Giblin-Davis and Jorge B. Pena

Semiochemical traps for monitoring the West Indian sugarcane weevil in palm nurseries have been developed and are in use in Belle Glade, Florida. Semiochem-ical trapping will have a significant impact on monitoring the West Indian sugarcane weevil as well as the palmetto weevil and other weevils. Although they cannot be relied on in a mass-trapping stragegy to lower the weevil's destructive potential in epidemics, they can show the presence of the weevil and the need and timing for contol.

Every year new insects that become pests and plant species that are attacked by native insects are introduced into Florida. Management of these as well as other insect pests requires balancing management of environmental resources with the production of plants for food, fiber and ornamentals. It also requires proper and wise use of pesticides as well as new methods of controlling insect pests such as insect resistant plants, biological control and insect behavior-modifying chemicals or semiochemicals.

Semiochemicals are chemicals that act as signals between organisms. Pheromones and kairomones are both semiochemicals, but pheromones act within a species providing signals to individuals in that species while kairomones provide signals between species, generally with the receiver benefiting. The most useful pheromones developed to date are aggregation and sex pheromones which insects use to locate food and mates. These pheromones are used primarily for monitoring insect populations and thereby allowing better timing of insecticide or control applications. In some cases they may permit mass-trapping with reduction in insect populations and the problems they cause. These semio-chemcals have relatively low toxicities, are biodegraded easily and can be used in extremely small quantities. Although insects and organisms produce these compounds, the identification and synthesis of some of these semichemicals can now produce a source of useable quantities of them.

Recent data from our laboratory suggests that the behavoirs of certain newly introduced or native weevil groups, including the palm and sugarcane weevils are affected by semichemicals. With partial support from the T-STAR program, male-produced aggregation pheromones of several palm and sugarcane weevils in the subfamily Dryopthorinae have been identified and synthesized. The pheromones comprise 8,9 or 10 carbon, methyl branched, sec-



Head of Metamasius hemipterus (seen with SEM).

ondary alcohols. The major aggregation pheromone of the West Indian sugarcane weevil, *Metamasius hemipterus sericeus*, and the South American palm weevil, *Dynamis borassi*, was identified as (4S,5S)-4-methyl-nonanol. (5S,4S)-5-methyl-4-octanol (cruentol) was identified as the aggregation pheromone for the palmetto weevil, *Rhynchophorus cruentatus*. Ethyl acetate, ethyl propionate and ethyl butyrate were shown to be important plant host kaironomes for the West Indian sugarcane weevil and the palmetto weevil.

Identification of these molecules has led to the development of effective monitoring tools and, thereby, improved protection of ornamental palms and sugarcane in Florida. For the West Indian sugarcane weevil, the most cost-effective semiochemical bait is a three-way combination of sugarcane, ethyl acetate and pheromone. For *R. cruentatus*, the most cost-

effective trap is a two-way combination of sugarcane and pheromone. Traps with greater surface area appear to work better. Attempts to integrate similar chemical ecology of *M.h. sericus* and *R. cruentatus* into an organized trap design for both species failed because pheromones for *M.H. sericus* caused lowered trap counts for *R. cruentatus* when pheromones from both species were present together.

The impact of *R. cruentatus* on growers of the Canary Island date palm, *Pheonix canariensis*, is substantial when it is allowed to get out of hand. An active, epidemic field site during 1997 yielded about 83,000 adult weevils. Loss to the grower at this site included eventual death of all trees and amounted to $285,000 to $380,000 based on the number of palms per hectare and a wholesale price of $300 - $400 for this size palm. Information is now being prepared to inform growers of the potential lethal risk that *R. cruentatus* poses for this non-native palm. The costs of aggressive phyto-sanitation at the first symptoms of infestation and prophylactic pesticide treatment at times of pruning, stress or transplanting should be factored into the predicted cost of production and maintenance of Canary Island date palms in Florida. To prevent the spread of *R. cruentatus* populations, Canary Island palms should not be transplanted from sites with an epidemic because early weevil infestations are not easily diagnosed and stressing of palms can call in colonizing weevils before removal from the nursery.

Optimized semiochemical traps designed by us for monitoring *M.h. sericeus* in palm nurseries are now being used in Belle Glade, FL.

Semiochemical trapping will have a significant impact on monitoring populations of *R. cruentatus* and *M.h. sercieus* but can not be relied upon in a mass-trapping strategy to lower the destructive potential of *R. cruentatus* during an epidemic in Canary Island date palm nurseries. Care should be taken when monitoring or mass-trapping in or near small plots of highly susceptible palms such as Canary Island date palms because pheromone could call more weevils into a site. We have tested a variety of pesticides that are toxic to the adults of *M.h. sericeus* and *R. cruentatus* and can be employed to knock populations down.

Dr. Giblin-Davis is Professor, FLREC, University of Florida, Ft. Lauderdale, FL, and Dr. Pena is Professor, TREC, University of Florida, Homestead, FL. *Collaborators in this research were Dr. Gerhard Gries and Dr. Regine Gries, Simon Fraser University, and Dr. Cam Oehlschlager of Chem Tica, and Dr. Tom Weissling, FLREC.*

Canary Island date palms dying from attack of R. cruentatus.

Pheromone trap for R. cruentatus and M. hemipterus.

Palmetto weevil (Rhynchophorus cruentatus) on sugarcane.

RICKETTSIA
from page 1

compared to other tropical fruits, and commercially significant production within the first year of planting. The market for papaya in Europe and North America is rapidly expanding. Papaya production freed from the constraints due to major diseases will offer an alternative high value crop for local farmers and an export commodity for the Caribbean region. The potential increases in acreage, production, and economic benefit to the region from overcoming the diseases is valued at millions of dollars and thousands of jobs.

Papaya bunchy top disease is transmitted by leafhoppers, and its geographic distribution coincides with that of its insect vectors. The disease affects the normal development of the trunk and foliage at the top of the infected plants. Flowering and fruit set rarely occur in affected plants. In advanced stages the plants become denuded except for a tuft of small leaves at the apex. Entire orchards can be affected.

The cause of the papaya bunchy top disease had been uncertain for many years impeding diagnosis, and the development and implementation of strategies to manage the disease. This situation led to coopertive research under a T-STAR project at the Universities of Florida and Puerto Rico investigating the cause of the disease. Microscopic examination of diseased tissues led to the discovery of a small, rod-shaped, gram-negative bacterium within the latex-producing cells (laticifers) of PBT-affected, but not healthy, papaya plants. Attempts to isolate this bacterium in culture were unsuccessful, impeding identification of the bacterium by traditional methods and verification of its pathogenicity to papaya plants. Nevertheless, the discovery was quite unique, providing the first evidence for a leafhopper-transmitted, laticifer-inhabiting, plant pathogenic bacterium.

Because the bacterium associated with the papaya bunchy top disease could not be identified by traditional methods, molecular methods were employed for identification. Portions of four genes were isolated from bacterium extracted from diseased plants. The genes were sequenced. Comparative sequence analyses consistently indicated that the bacterium is a member of the genus *Rickettsia.* The sequence information furthermore facilitated development of a polymerase chain reaction procedure for the specific detection of the bacterium and diagnosis of the disease. The rickettsia was detected by polymerase chain reaction in diseased, but not healthy, papaya tissues and in leafhopper vectors providing further evidence of the causal role of the bacterium in the disease. Although *Rickettsia* have been found naturally in arthropods and can be pathogenic to man and other vertebrates, this was the first evidence of its kind implicating a *Rickettsia* as a plant pathogen.

Chloroplasts and mitochrondia are plant organelles involved in photosynthesis and energy transfer. These organelles are thought to have evolved from bacteria that had a symbiotic relationship with primitive plants. The present day rickettsias appear to be the closest living relatives of those bacterial symbionts from which mitochrondria evolved. However, until the papaya bunchy top bacterium was discovered, rickettsias were not known to inhabit plants. The discovery of the papaya bunchy top rickettsia therefore provides further evidence for the evolutionary linkage between rickettsias and a plant organelle. Thus, this T-STAR supported research has provided new information that extends fundamental knowledge and provides an economically important technology for expanded production of a highly nutritious fruit crop in the American tropics.

Dr. Davis is a Professor and Mr. Zing is a Technician at the University of Florida, Homestead, FL. Dr. Brunner, Dr. Pantoja are Professors and Mr. Ferwerda is a Graduate Student at the University of Puerto Rico, Mayaguez, PR.

Larval and Pupal Parasitoids Offer Potential for Managing Fruit-piercing Moths in Micronesia

R. Muniappan

Recent research and field surveys of primary and secondary fruit-piercing moths and the biological agents that attack their developmental stages (eggs, larvae and pupae) suggest that the introduction of larval-pupal parasitoids of these pests would be of value in protecting and increasing the production of tropical fruits in Micronesia. T-STAR research will introduce and evaluate such a biocontrol agent.

Fruit-piercing moths are found all over the world and represent a group of specialized lepidopterans that feed as adult moths on cellular sap of various fruits.

Damage to citrus produced by O. fullonia.

Fruits attacked by the adult moths soon become dry and pulpy and lose their edible appeal. Fruit-piercing moths are generally of two types: (1) those with strong probosces (highly sclerotized and frequently barbed) called primary fruit-piercing moths, and (2) those without strong probosces, sclerotization or barbs called secondary fruit-piercing moths. The primary type can penetrate the skin and pulp of fruits to feed. The secondary type generally require an existing puncture or hole, such as that made by a primary moth or other means, to be able to feed. In addition to the injury caused by piercing and feeding, such penetration through the skin of fruit can lead to secondary infections in the fruit.

University of Guam scientists surveyed the distribution and pest status of fruit-piercing moths of Micronesia. Four species of primary and 19 species of secondary fruit-piercing moths in Micronesia have been surveyed and studied including their distribution, life cycle, host plants of various developmental stages of the moths, biological agents attacking them, and maximum wingspan. Also, the scientists have reviewed the effectiveness of different methods of control including chemical pesticides, hand-catching, covering ripening fruit, destruction of trees harboring eggs and larvae and biological agents.

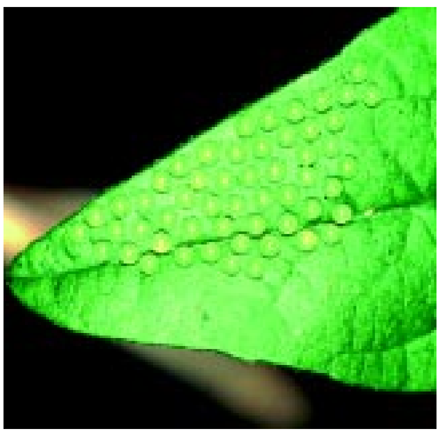
Proboscis of an adult O. fullonia.

Fruit-piercing moths are serious pests throughout much of Micronesia and have greatly hindered the commercial development of tropical fruit production within the region. Currently, *Othreis fullonia* (Clerck), a primary fruit-piercing moth, is one of the most troublesome and widespread species ranking among the top 10 most serious pests of the Pacific region. Over the past few decades, there have been a steady influx of other fruit-piercing moth species into the area possessing similar fruit damaging potential.

While there is seldom a single method of effective pest control

➥ page 6

Larval stage of *O. fullonia.*



Egg mass of *O. fullonia.*

Othreis fullonia on guava, Guam.

Fruit-piercing moth damage to star-fruit.

for many pest species, biological control using host-specific natural enemies has met with considerable success in many areas of the world. On Guam, the natural enemies of the primary fruit-piercing moth, *O. fullonia*, substantially reduce the number of egg laying adults that reach maturity. Egg parasitoids alone cause about 85 percent egg mortality in this species. This notwithstanding, the survival of the adult moth population remains high enough to cause significant damage to locally grown fruits and vegetables throughout the island. Additional biological and cultural control measures are therefore warranted to augment and improve the effectiveness of existing natural enemies on Guam and throughout Micronesia.

Scientists in the Entomology Unit, College of Agriculture and Life Sciences, University of Guam, are focusing on potentially useful larval-pupal parasitoids from other parts of the world. Plans are currently underway to introduce the host-specific eulophid wasp, *Euplectrus maternus* Bhatnagar, from India to Guam. The efficacy of this larval parasitoid in its native lands is very encouraging. There is good reason to believe that it will make a significant contribution to the control of *O. fullonia* on Guam once it has become established. The reduction in this and other primary fruit-piercing moth populations through biological control could result in a reduction in the abundance of secondary fruit-piercing moth populations, thus providing multiple effects.

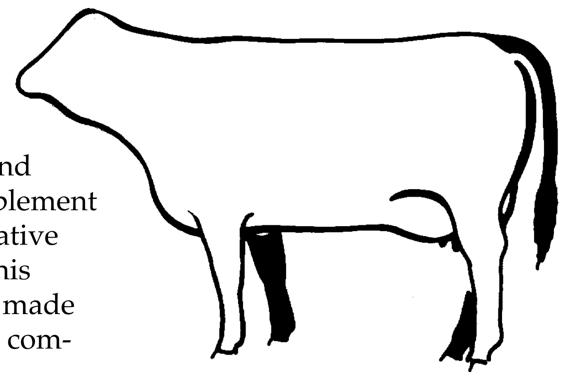
This introduction of the larval parasitoid from India and its evaluation in Guam is supported by a Tropical/Subtropical Agriculture Research (T-STAR) grant.

Adult of *O. fullonia.*

Dr. Muniappan is Professor Emeritus of Entomology, the University of Guam, Mangilao, Guam.

Modeling Effects of Supplements on Performance of Forage-Fed Beef Cattle

John E. Moore and William E. Kunkle



When forage-fed cattle are supplemented, changes in animal performance may be more or less than expected. Supplementation effects on forage intake and diet digestibility can be predicted with simple equations and computer models.

Forages consumed by beef cattle in tropical and subtropical environments vary in quality due to differences in species, maturity, environment, and management. When quality is low, forages alone may not support desired rates of animal performance. In such cases, it is necessary to supplement with protein and energy, as well as minerals.

When forages are supplemented with concentrates, however, the effects on animal performance are often highly variable and unexpected. These variable responses are due to associative effects among forages and supplements that affect voluntary intake of the forage and digestibility of the total diet.

The many possible combinations of forages and supplements make it difficult to determine the optimum supplementation program for a particular situation. It is necessary to know 1) requirements of the specific animal in its environment, 2) quality and composition of the specific forage being consumed, 3) amount and composition of the supplement being fed, and 4) associative effects. Combining all this essential information is made easier by well-designed computer programs.

The objective of this T-STAR project was to describe associative effects mathematically, and to develop prediction equations for use in computer programs. A database was constructed on non-lactating cattle consuming forage ad libitum with and without supplements. The database included 66 publications on 126 forages (73 harvested and 53 grazed), and a total of 444 comparisons between a control, non-supplemented treatment and a supplemented treatment.

Supplements generally but not always increased average daily gain (ADG). In many cases, small amounts of supplement increased gains, especially with native forages and straws. The least ADG response to supplement was seen with native forages supplemented with molasses alone or with low intakes of molasses containing high levels of urea. The greatest response was seen with improved forages, when supplements were either dry feeds or molasses plus added protein, and when supplemental Crude Protein (CP) intake was > .05% of body weight (BW).

Supplements had large effects on voluntary forage intake. The change in forage intake due to supplement ranged from -1 to +1% of BW. Generally, supplements decreased intake with improved forages, but with native forages and straws supplements both increased and decreased forage intake. This discrepancy may be related to the ratio of Total Digestible Nutrients (TDN) to CP in forages, an indicator of the amount of protein relative to available energy.

When supplements increased forage intake, there was a deficit of protein relative to available energy (forage TDN:CP ratio > 7). Supplements decreased intake when there was adequate protein (forage TDN:CP ratio < 7). Intake decreased also when forage intake fed alone was high (>1.75% of BW), or when supplemental TDN intake was high (>.7% of BW).

➥ page 9

MEALYBUG
from page 1

feeding that makes pineapple fruit surfaces sticky and eventually blackened, due to an associated fungus called sooty mold. Perhaps the greatest threat is the mealybugs' ability to transmit and interact with plant pathogens, thought to be closteroviruses, that often kill pineapple plants when plants are stressed via mealybug feeding. In Hawaii, the most common mealybug attacking pineapple is the pink pineapple mealybug, *Dysmicoccus brevipes* (Cockerell), (Homoptera: Pseudococcidae). A close cousin called the gray pineapple mealybug, *Dysmicoccus neobrevipes* Beardsley, also infests plantings. Like aphids, mealybugs are often found in association with ants (e.g., the big-headed ant) that prudently oversee the mealybugs, providing protection in exchange for honeydew. Ants protect the mealybugs from their natural enemies including small wasps that act as parasites on the mealybugs and from predators such as ladybugs. They also remove excess honeydew that inhibits mealybug reproduction and dispersal if mealybugs become entangled in the accumulated feeding by-product. Ants are very important to the mealybugs' survival, and elimination of the ants using poisonous ant baits, will usually result in destruction of the mealybug colonies. Therefore, farmers routinely use ant baits in their pineapple fields to eliminate the mealybugs' guardians. Although this is an efficient and evidently safe management system, farmers have no "backup" control systems if the ant baits suddenly become unavailable or less effective. Recently in Hawaii, control failures have occurred for unknown reasons.

This project's major goal is to determine the potential of using periodic releases of one of the pink pineapple mealybugs' most effective natural enemies, the encyrtid parasitoid *Anagyrus ananatis* Gahan. Field data indicate that this natural enemy can attack mealybugs in the presence of ants, although its impact on mealybug mortality is low due to ant interference. Laboratory studies indicate that the female parasitoids avoid ants and are rarely killed, unlike predators such as the ladybugs. When ants are absent, the parasitoid is a highly effective mortality agent, reducing the mealybug populations in pineapple plantings.

Before one can conduct periodic releases of millions of *Anagyrus ananatis*, they must first be reared under artificial conditions. Large numbers of the mealybugs are required to feed the parasitoids so they can reproduce. Until recently, it was difficult to efficiently rear large numbers of the pink pineapple mealybug in the laboratory. Individuals often fell off of the squash fruit used as a food source and they often became stuck in their own honeydew because ants were not present to eliminate the honeydew. Solving these problems was simple, but contrary to logical thinking. Mealybug-infested squash were actually buried in a substrate

The encyrtid parasitoid, Anagyrus ananatis *investigates an adult pink pineapple mealybug within cheesecloth layers.*

Big-headed ants (note soldier with large head) provide protection and sanitary services for pink pineapple mealybugs in exchange for honeydew.

Pink pineapple mealybugs feeding on Rhodes grass just below the soil surface. Weeds around pineapple plantings may provide a source for mealybug infestations.

MEALYBUG
from page 8

called vermiculite, commonly used for plant propagation. It consists of light and absorbent particles that flow like sand or fine soil. An average sized squash (12–16 cm long & about 0.5–1.1 kg) produced about 4,000 large 3rd instar and adult (> 0.85 mm in size) and 2,500 2nd instar and small 3rd instar (0.5–0.85 mm in size) mealybugs, 5–7 weeks after the initial infestation with 1,000–2,000 adults. This does not include the thousand's of first-instar crawlers (dispersal stage) produced by the mealybug adults. Efforts are underway to further increase production efficiency.

Like growing plants, rearing insects can be challenging. Initial production of the parasitoid *A. ananatis* was very low given the natural enemy's reproductive potential. The available numbers of mealybug hosts was not the limiting factor but rather the manner in which they were offered to the parasitoids. By accident, it was discovered that when 3rd instar immature and adult mealybugs were placed within a few layers of cheesecloth and then exposed to the parasitoids, the numbers of offspring produced were 6-fold greater than the parent generation. Refinement of this technique continues as the effects of exposing different aged mealybugs on parasitoid offspring size and sex ratio are appraised. Additionally, future work will determine optimal storage conditions for mass produced parasitoids as well as delivery methods to the field. These studies are supported by a T-STAR Grant.

Dr. Johnson is a Professor of Entomology and Mr. Pandey is a Ph.D. graduate student at the Department of Entomology, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Honolulu, Hawaii.

FORAGE-FED BEEF
from page 7

When forages were supplemented, observed diet TDN concentration deviated from expected TDN by -10 to +5% of dry matter. When diet TDN was greater than expected, the forage was a native hay or straw in most cases. When supplemental TDN intake was high (> .7% of BW), diet TDN was generally less than expected.

Using the data set described above, equations were developed to predict associative effects of supplements. Inputs for estimating voluntary forage intake when fed with supplement included voluntary forage intake when fed alone (a function of forage quality), supplement intake, forage and supplement CP and TDN, and codes describing forage types and supplemental energy sources. The equation to estimate total diet TDN was based on expected total diet TDN calculated from the intakes and TDN of forages and supplements.

The equations developed here account for a large part of the effects of supplements on forage utilization. These equations, and the nutritional models in which they are incorporated, require only simple, reasonably available inputs. These models are unique in that they consider the associative effects between forages and supplements that affect forage intake, diet digestibility, and, thus, animal performance.

Two types of models were developed: 1) a static model to estimate animal response to a known quantity of supplement intake, and 2) an iterative model to compute the amount of supplement required to achieve a desired rate of animal performance. It is estimated that application of these models in formulating supplements for heifer development programs would result in a 15% reduction in supplemental feed costs, or a savings of $5 per head at current prices. In Florida alone, this technology could be applied to 60,000 replacement heifers each year for a savings to the beef industry of $300,000 annually.

Dr. Moore is Professor Emeritus and Dr. Kunkle is Professor and Beef Cattle Extension Specialist in the Animal Science Department, University of Florida, Gainesville, FL.

Molecular Biology and Genetic Engineering Studies on Forage Grasses

Rex L. Smith and He Xu

New genetic engineering research results suggest that the quality and digestibility of tropical and subtropical perennial grasses used as forage for animals in tropical and subtropical areas can be increased thereby increasing the capabilities for animal production.

Livestock industries of Florida, the Caribbean and other tropical areas are based upon the production and utilization of warm season perennial grasses. These tropical and subtropical forage species generally have inadequate forage quality and digestiblity imposing major constraints on animal performance and productivity. Lignin and its phenolic monomers and degradation products in these species are major factors lowering the digestibility of grass cell walls and reducing microbial activity by presenting a physical barrier to microbial attack and/or by providing phenolic lignin degradation products with antimicrobial activity.

Traditional plant breeding techniques have been slow and limited in improving forage quality and digestibility even though genetic variability exists in lignin content of forage grasses. Molecular biology and genetic engineering offers promise for improving forage grass quality and animal productivity by reducing or modifying the type of lignin produced in grass. The lignin biosynthetic pathway and many key enzymes are well understood. Furthermore, brown midrib mutants of maize and sorghum with defective O-methyltransferase (OMT) and cinnamyl alcohol dehydrogenase (CAD) lignin biosynthetic genes have been shown to produce modified as well as reduced amounts of lignin compared to normal plants. Those mutants have given improved forage digestibility and animal performance of up to 20%.

The research in this T-STAR project focuses on the use of molecular biology and genetic engineering to modify lignin biosynthesis to improve forage grass quality. To that end, two lignin biosynthetic genes (OMT and CAD) have been isolated and cloned in Pennisetum and sorghum. Needed genetic engineering technology (particularly tissue culture and transformation) for forage grasses has been lagging behind that of food and cash crops. Consequently, we selected maize as our model crop to evaluate the technology to modify lignin synthesis.

A repeatable monocot transformation system was established. Antisense constructs were assembled to drive the sorghum OMT in the reverse direction. Those constructs also contained the bar selectable marker gene, giving resistance to glufosinate herbicide, which permits selecting transformed cells by using that herbicide in the culture media. Maize transformation was accomplished by microprojectile bombardment of callus tissue, following selection for transformed cells on media containing 2-5 mg/l glufosinate; callus was regenerated into plants. Transgenic plants were identified by resistance to glufosinate, PCR amplification of the bar gene and Southern analyses.

Transgenic plants have been identified with OMT activities being reduced as much as 60% compared to control plants. In addition, several transgenic plants have expressed the "brown midrib" phenotype. Both OMT activity reduction and the brown-midrib phenotype are heritable and are being evaluated in the next generations. Gene expression studies using northern analyses have shown that the normal OMT transcripts observed in control plants are missing in transgenic plants. This suggests that the expression product of the antisense OMT constructs causes degradation of the normal OMT transcripts. Preliminary in vitro organic matter digestability (IVOMD) values are higher in transgenic plants than in control plants.

Further characterization of the transgenic plants is in progress to evaluate the effect of reduced OMT activity on lignin content,

and also whether lignin type has been modified as it is in the natural brown-midrib mutants. Research is also being initiated to extend this technology to bahiagrass, Pennisetum sp. and other tropical forage grasses.

Future improvement in animal performance and productivity will likely be accomplished with increased quality and utilization of tropical and subtropical forages rather than from further increases in grass yields. Since large areas in Florida, the Caribbean and the tropics are devoted to the production of forage grasses, the application of molecular genetics and genetic engineering to improve quality of forage grasses could have a large economic and cultural impact through improved animal performance and productivity.

For example, Florida now has 2.5 million acres in bahiagrass and since genetic engineering of that species is now possible this T-STAR research is targeting it as a species within which lignin composition and quantity might be manipulated. With that large acreage, even small increases in forage quality can produce significant returns. This technology also has the potential of being applied to all forage grasses grown in Florida, the Caribbean and other tropical areas.

Dr. Rex Smith is a Professor and Mr. He Xu is a Ph D graduate student in the Department of Agronomy, University of Florida, Gainesville, FL.

Biocontrol of Crop Aphids on Guam

Ross Miller

Background research and surveys, sponsored by T-STAR, on aphids and aphid natural enemies on Guam and in the Commonwealth of the Northern Marianas Islands of Saipan, Tinian and Rota have led to cooperative international research on the potential use of hymenopteran parasitoids for biological control of aphids in these areas.

Extensive surveys of aphids and aphid natural enemies have been conducted on Guam and in the Commonwealth of the Northern Marianas Islands of Saipan, Tinian and Rota under the auspices of the T-STAR project "Reducing Pesticide Use in the Marianas Islands Through Biological Control of Aphids." Results from these surveys, show that a number of aphid pests have been inadvertently introduced over the years onto farms in the Marianas Islands. These small soft-bodied insects cause serious cosmetic damage and yield loss in crops and ornamental plantings, and vector a number of harmful viral diseases. The initial founder populations of aphids in the Marianas were likely not infested with parasitoids when the aphids were introduced. Therefore, the rich natural enemy complexes that normally regulate aphid numbers in their home range are not present on Guam or in the CNMI.

Guam's humid tropical environment allows aphid populations to increase at a phenomenal rate year round, forcing commercial farmers, home gardeners and professional horticulturists to rely on chemical insecticides. On Guam, bean plants infested with a few cowpea aphids, *Aphis craccivora*, are completely inundated within a few days. If left untreated, the plants die within 3 to 4 weeks. Interestingly, bananas on Guam are frequently infected with "bunchy top" virus vectored by the banana aphid, *Pentalonia nigronervosa*. Banana aphids in the Marianas are more commonly found on common ornamentals and provide a ready source of aphids for nearby banana plantations. Cucurbits in the Marianas are nearly always infested by the melon aphid, *Aphis gossypii*. The melon aphid also infests taro, cotton and a number of other crops. Brown citrus aphid, *Toxoptera citricida*, is

➥ page 12

APHIDS
from page 11

the most common aphid infesting lemons, oranges, tangerines, and calamansi on Guam. The black citrus aphid, *T. aurantii* is also present.

Dr. Ross Miller of the University of Guam (UOG), Dr. Keith Pike of Washington State University (WSU), and Dr. Petr Stary of the Czech Academy of Sciences have collaborated in identifying aphids and their hymenopteran parasitoids. They also developed a production line for rearing and releasing a promising parasitoid, *Aphidius colemani*, on Guam aphids using methods developed by Dr. Stary at his laboratory in the Czech Republic. Production has been developed and setup at the Irrigated Agriculture Experiment Station (IAREC) in Prosser, Washington. Pure cultures of adult *A. colemani* and aphid mummies containing developing parasitoids are produced about every eight weeks for transshipment to Guam. On Guam, Dr. Miller releases them into unsprayed aphid-infested fields at UOG's experimental stations, and on cooperating farmers' fields. An additional parasitoid, *Diaeretiella rapae*, was also cultured at the IAREC laboratory and carried to Guam.

Post-release surveys have shown that *A. colemani* and *D. rapae* both successfully attacked Guam aphids and formed mummies. Scientists, local farmers and gardeners are hopeful that increased numbers of aphid parasitoids in their fields will soon result in reduced aphid infestations and fewer sprays.

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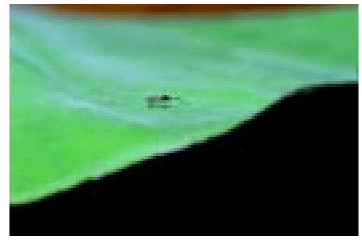
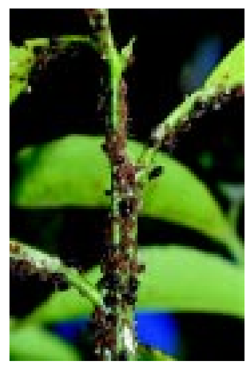


Aphidius colemani on leaf.

Release of parasitoids.



Brown citrus aphid, Toxoptera citricida.

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