Caribbean Basin Administrative Group

TROPICAL AND SUBTROPICAL AGRICULTURE

Research notes

summer 98

Pacific Basin Administrative Group

Effluents From Fish Tank Cultures Prove Effective Fertilizer For Pak Choi Production

William M. Cole, Manguel C. Palada, Stafford M.A. Crossman, Kurt A. Schultz and Jacqueline A. Kowalski

Pak choi plot, irrigated and fertilized with aquaculture effluent, is equally productive as plots grown with conventional methods.

Multiple use of scarce resources (water, nutrients and fertilizer) in fish culture, irrigation and fertilization increases techniques for sound resource management and waste disposal. Chemical analysis and field trials of water and sludge from fish culture tanks showed the adequacy of these resources to raise fish as well as irrigate and fertilize pak choi production. Yields of pak choi using culture tank water and sludge were comparable to or higher than yields obtained using commercial fertilizer and rain water. Such sound resource management techniques are essential as the demand for fresh water and effective disposal increases on Caribbean islands.

Shortage of freshwater resources limits both fish and vegetable production in the Virgin Islands. Irrigation from well water and rainwater catchment are required to maintain steady production. Tanks or plastic-lined ponds used for water storage can also be used to raise fish using the water for two purposes. Intensive fish culture in such tanks reduces land and water requirements. Double use of the water as well as nutrients as fish food and its sludge as fertilizer save and manage resources.

A study was conducted at the University of the Virgin Islands Agricultural Experiment Station to determine tilapia production and quality of water in outdoor tanks used for production of this fish and to compare tank water and sludge from tilapia production with commercial fertilizers for the production of pak choi (*Brassica*

➥ *page 3*

Bacterial Blight of Anthuriums Suppressed by a Mixture of Four Bacteria

Ryo Fukui, Hisae Fukui and Anne Alvarez

A mixture of four bacterial species was highly effective in reducing bacterial blight of anthuriums in greenhouse experiments. Bacterial blight of anthuriums has spread rapidly throughout the tropics and subtropics from Jamaica to the Philippines severely affecting local economies. The suppressive effect of the new bacterial mixture provides ways of enhancing and maintaining such disease suppression under field conditions.

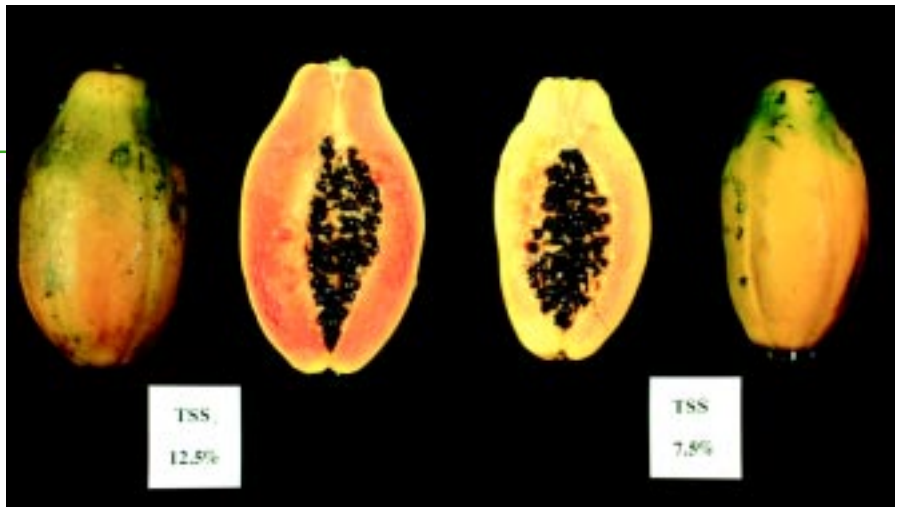
Bacterial blight of anthurium, caused by *Xanthomonas campestris* pv. *dieffenbachiae* (*Xcd*) is a persistent threat to anthurium growers and can be very destructive if conditions favor spread of the disease. Antibiotic sprays, first used to combat blight, were abandoned in the early 90's because of their high cost and failure to eliminate antibiotic resistant *Xcd* strains. Other

➥ *page 8*

PAPAYA
A Sweeter Fruit

Robert E. Paull, David Christopher and Lili Zhou

Studying the processes affecting leaf - fruit relationships in papaya is leading to sweeter fruit.



Papaya is grown in Caribbean and Pacific areas because of its strong export potential. Papaya sometimes has low sugars (<10%) and poor flesh color when ripe, severely affecting market quality. A 1994 inspection in Honolulu found 15 to 40% of the papayas were green with sugar contents varying from 6.7 to 10.1%. Standards for Hawaii's papaya requires a minimum of 11.5% sugars. To expand the export of this fruit, growers and shippers need to continually improve the quality and flesh color of shipped fruit.. Fruit sugars are crucial for flavor and marketability.

Papaya with low sugar content cannot be visually culled after harvest because there are no obvious external symptoms. Four of the reasons suggested as causes of low sugars are: 1.) harvesting immature and green fruit without a trace of skin yellowing; 2.) diseases such as a virus or a pathogenic mycoplasma-like organism (MLO), 3.) reduced photosynthesis resulting from the loss of active leaves due to strong winds, drought, disease, insect feeding or other environmental stress; or, 4.) high self-shading and low temperatures in the field. Harvesting green fruit limits the accumulation of desirable sugars, while fruit grown in the reduced light of the cooler part of the year also has lower sugars. No pathogenic organism has been detected nor demonstrated as a cause. A T-STAR research project at the University of Hawaii focused on the third and fourth possibilities by studying the processes affecting the relationship between leaves and fruit during papaya fruit growth.

Once initial flowering occurs, the papaya tree flowers and sets fruit continuously, requiring an uninterrupted supply of sugars for fruit growth and development and sweetness and full flavor. Developing fruit have a very strong demand for sugars supplied from the leaves where they are produced by photosynthesis. Papaya lacks stored sugar reserves, such as starch found in banana, and must remain attached to the plant to accumulate sugars. During papaya fruit development, total sugar content increases slowly during the first two thirds of fruit development, then increases rapidly during fruit ripening. Variety, timing of harvest and ripening stage of fruit are major factors influencing final sugar composition of papaya.

The leaves of papaya are, however, frequently damaged by hurricane, insects, disease, soil nutrition deficiency and environmental factors. As a result of reduced leaf area, and hence photosynthesis, fruit growth and sugar accumulation are reduced. Fruit sugar levels though genetically controlled are significantly reduced by leaf loss. Despite the importance of leaf photosynthesis to fruit sugars and quality, no direct information was available on the impact of leaf loss and the balance between leaves and fruit on a papaya plant. This T-STAR project brought together field determination of this balance and investigated the enzymes having the greatest impact on fruit sugar accumulation.

During a 24-week experimental period, removal of 75% of papaya leaves reduced new flower and fruit set and decreased sugar level in ripe fruit within 2 weeks after defoliation. There was no immediate effect on fruit production, average fruit size, percentage of fruit flesh and seed, and seed dry weight. Continued removal of mature leaves resulted in lower new fruit set (25% of control), smaller fruit size (77% of control), and lower fruit sugars (85% of control).

When the number of fruit on a papaya plant was reduced by fruit thinning there was an increased new fruit set and ripe fruit sugar content in papaya varieties 'Line-8' and 'Sunset' but not 'Kapoho'. Average ripe fruit weight was increased in 'Kapoho', but not 'Sunset or 'Line-8' varieties. Fruit thinning also increased the sugar levels in the fruit remaining on plant.

➥ *page 10*

PAK CHOI
from page 1

rapa L. Chinenses). Accumulation of sludge during fish culture required that comparisons include tank water from which sludge had been removed with tank water from which the sludge had not been removed.

Mean concentrations of total ammonia-nitrogen, nitrite-nitrogen and dissolved oxygen were not significantly different in outdoor tanks when solids were removed or not removed. But nitrate-nitrogen, the primary form of inorganic nitrogen in the rearing tanks, was significantly higher in tanks where solids were removed increasing from approximately 10.5 mg/L to 161.9 mg/L in tanks with solids removed and to 94.3 mg/L in tanks without solids removed. Total phosphorus and potassium concentration increased over time. By the end of the experiment, the total suspended solids concentration was 1250 mg/L in tanks without solids removed compared to 368 mg/L with removal. Total phosphorus, total suspended solids and chlorophyll *a* were approximately 15, 49 and 34 times higher in the tanks with sludge than those with sludge removed.

Although feed conversion ratios and survival did not differ between the presence or removal of sludge, tilipia cultured in outdoor tanks with solids removed had a significantly higher growth rate and final weight than fish cultured in outdoor tanks where solids were not removed. The water and nutrients used to culture were highly effective in tilapia production.

In field trials, pak choi fertilized weekly with sludge were significantly larger than pak choi plants fertilized with granular fertilizer or water from either tanks with or without sludge removed. Similar results were observed in a second trial. In both trials, yields of pak choi fertilized with rearing tank water or sludge had total yields similar to or higher than those fertilized with the inorganic fertilizers.

Ammonia, the primary metabolic waste product of most fish, is toxic to most fish at low concentrations and must be removed from intensive culture systems. Water quality results from this study indicate that nitrification occurred in the water column of both tank systems - nitrate-nitrogen increased over time. Relatively high concentrations of total phosphorus, total

➥ *page 9*

A New Strategy for Genetically Engineering Resistance in Plants to Geminiviruses

Charles A. Powell, Y.P. Duan and Ernest Hiebert

A new procedure has been developed which produces, finds and isolates genes for resistance to geminiviruses. The procedure includes introducing these genes into tobacco and tomato plants thus making it possible to engineer plants that are resistant to tomato mottle geminivirus.

Geminiviruses are important pathogens of vegetable crops in tropical and subtropical regions of the world. Two of these viruses, tomato mottle geminivirus (TMoV) and tomato leaf curl geminivirus (TYLCV) have caused significant losses in tomatoes in recent years. TMoV has reduced tomato production in Florida since 1989. TYLCV, which frequently makes growing tomatoes unprofitable in Asia Minor, the Middle East, and Northern Africa, has recently been detected in the Caribbean Region including Puerto Rico and Florida.

Control of geminiviruses in vegetables has largely relied on insecticides and physical exclusion of their insect vectors from transplants using screen houses. These methods have been successful in some cases, such as the use of Admine to control TMoV, but their long term efficacy is questionable because of concerns over cost, development of resistance and the environment.

Several years ago a project to develop genetic resistance to TMoV by transforming plants with virus genes (pathogen-derived resistance) was funded under the T-STAR program. When the TMoVC BC-1 gene, which is involved in movement of the virus and the induction of symptoms in the plant, was transferred into tobacco plants, many of the plants showed symptoms similar to virus infection. However, some plants that should have contained the BC-1 gene and expressed virus-like symptoms, did not show any symptoms. Molecular analysis of these symptomless plants revealed that they did in fact

➥ *page 4*

GEMINIVIRUS
from page 3

contain the BC-1 gene, but it was in a mutated form. When tobacco plants containing the mutant BC-1 genes were exposed in the greenhouse to high concentrations of whiteflies carrying the TMoV virus, the plants showed resistance to the virus. The resistance conveyed by the mutant virus gene appeared to be general rather than specific; it also protected tobacco from another distantly related geminivirus (cabbage leaf curl virus). The mutated BC-1 gene has been transferred into tomatoes and the transformed tomatoes are currently being evaluated for resistance.

Thus, the T-STAR project not only led to plants resistant to TMoV virus, but also resulted in a procedure for developing resistance to other geminiviruses such as TYLCV.

The procedure may also be applicable to other plant pathogens such as bacteria and fungi. In plants where genes toxic to plant cells have been identified, mutations can occur readily in transferred genes during the plant transformation process. During transformation with rival genes whose products are toxic to the plant cell, mutated, non-toxic forms of the gene can be selected during regeneration and propagation processes. This process can result in a number of transformed, symptomless plants with high levels of resistance to the virus. Thus, by isolating a symptom-inducing gene or plant cell-toxic gene and transferring it into a crop plant for the development of pathogen-derived resistance, this procedure can be applied to other plant viruses and pathogens. Plants are screened based on symptoms, and those transformed plants that don't show symptoms are evaluated for pathogen resistance. Experiments using this protocol to produce tomato plants resistant to TYLCV are in progress. ■

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Two Possible Techniques To Increase Milk Production in Heat-Stressed Dairy Cattle

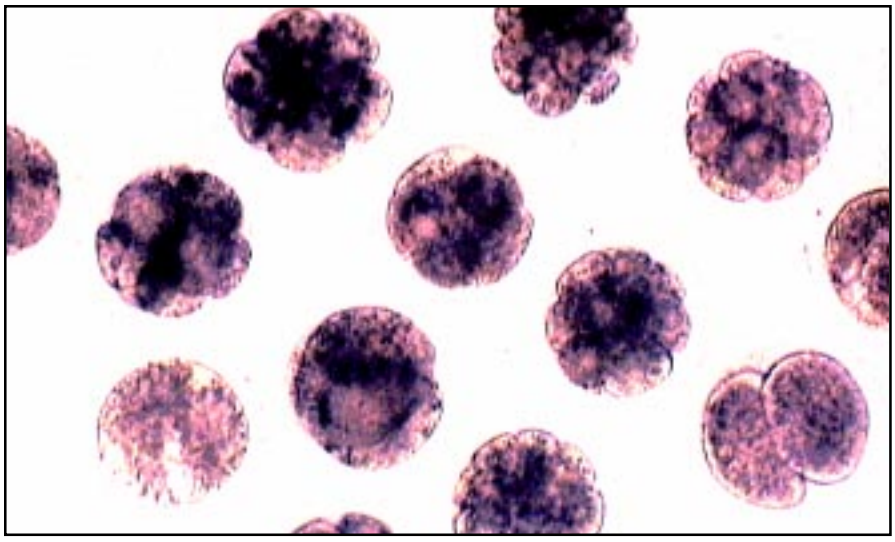
Peter J. Hansen, Carlos F. Arechiga, and Robert W. Godfrey

Heat stress, such as experienced by this cow, can have adverse effects on fertility of dairy cattle throughout the Caribbean region. Recent research on the use of timed artificial insemination and antioxidant administration has pointed the way to strategies for achieving some grains in reproductive performance during heat stress.

Dairy cattle throughout the Caribbean Basin suffer lower milk production caused by infertility due to exposure to heat stress caused by high air temperatures, solar radiation and, in some cases, humidity. New research has pointed the way to two, and possibly more, solutions.

Knowledge of the nutrition and genetics as well as improvements in management of dairy cattle over the past 50 years have led to an increase in the average annual milk yield per cow in the United States, increasing from 2,080 kg/lactation/animal in 1940 to 7,258 kg in 1994. One consequence of a cow's increased ability to produce milk is that the large metabolic demands for lactation cause high internal heat production making it difficult for lactating dairy cows to maintain a constant body temperature when exposed to heat stress. Elevated body temperatures can disrupt a variety of physiological functions including feeding and impregnation. For the dairy farmer, the result is less milk production because of less feeding and difficulty in impregnation.

The effect of heat stress on cow's reproduction and consequently milk production is large and can be understood easily in a couple of ways. In cooler periods of the year, inseminated cows that become pregnant range between 30 and 50%: while under heat stress this value can be reduced to less



Bovine embryos in the early stage of pregnancy, such as these shown here, are compromised by exposure to heat shock. Some protection from heat shock can be achieved if cultured embryos are exposed to antioxidants. Experiments are underway to test whether antioxidant administration can improve pregnancy rate in heat-stressed cows.

than 10%. During cooler periods of the year 50% of cows displaying symptoms of estrus - the period in its 21-day reproductive cycle when cows are sexually active and should be inseminated - are generally detected while only about 20% are detected in the summer. Failure to detect - meaning a cow will not be inseminated during its cycle - and reduction in pregnancy following insemination both will result in large reductions in milk production and large economic losses. The period between calving is lengthened so that cows spend more time in that part of their lactation when milk yield is low or non-exitant. Seasonal distribution of calving becomes skewed resulting in fewer than needed cows producing milk during certain seasons of the year.

Michael DeLorenzo of the University of Florida, using a dynamic modeling process to calculate the economic importance of improving pregnancy rate, estimates that increasing pregnancy rates (the product of estrous detection rates and the rate of pregnancy following insemination) from 15 to 30% would increase net revenue per cow per year by about $190. Multiplying the 180,000 cows in Florida by this figure represents a net return to the state of $34,200,000.

Recognizing the importance of the factors discussed above, recent research partially funded under the T-STAR program is pointing the way to strategies for improving reproductive performance during heat stress. If artificial insemination is to be successful, semen must be deposited in the reproductive tract close to the time when the cow releases its egg (i.e. undergoes ovulation). Such timing is generally achieved by inseminating cows when they display behavioral signs of estrous. Milo Wiltbank (University of Wisconsin) and Bill Thatcher (University of Florida) have independently developed schemes using hormonal treatments to synchronize time of ovulation in groups of cows. Inseminating cows without the need for estrous detection could, theoretically, reduce or eliminate losses caused by the effect of heat stress on estrous detection. We evaluated this procedure, called timed artificial insemination. Using this procedure in the summer we were able to demonstrate an increase in the proportion of cows pregnant by 90 days after calving from 9.8 to 16.6% in one study and from 14.3 to 34.3% in another. Bill Thatcher and Michael DeLorenzo using a separate set of their data and dynamic modeling estimated a net return per cow of $25.36 for timed artificial insemination for first service.

Another possible approach in preventing problems caused by heat stress is the administration of antioxidants to block some of the embryonic mortality occurring in heat-stressed cows. Much of such embryonic loss is believed to occur from exposure to elevated temperatures in the reproductive tract. In part, elevated temperatures may kill embryos by increasing production of oxygen free radicals, harmful by-products of normal oxygen metabolism. In culture, such lethal effects can be reduced by the provision of antioxidants that scavenge free radicals. Recently, we evaluated the effectiveness of antioxidant administration in lactating cows by supplemental feeding of the antioxidant *B*-carotene on the fertility of heat-stressed dairy cows. The percentage of cows fed *B*-carotene for at least 90 days that were pregnant by 120 days postpartum increased from 21.1 to 35.4%. Milk yield was increased by 4.2 to 6.1 lb/cow/day.

Additional research is necessary to confirm these effects of *B*-carotene and to test other antioxidants. A promising candidate antioxidant is a commercial preparation of vitamin E and selenium which can increase fertility in the absence of heat stress. While procedures have not been optimized, development of methods such as antioxidant administration and timed artificial

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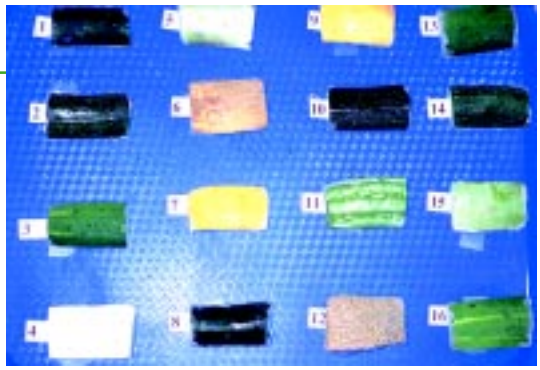
Development of Sustainable Vegetable Agroecosystems Through Technology Integration

Joseph DeFrank and Hector Valenzuela



Eight different cucurbit fruits were exposed to female Melon Flies to determine egg-laying preference. Green and yellow zucchini were the most preferred.

Trap crops and living grass sods in vegetable plantings are suppressing insects and weeds without chemicals.

Carefully planted crops are attacked by a variety of insect pests. For years pesticides have been the means of saving a crop. A major drawback to this approach is the production of an insect population with resistance to pesticides. Researchers at the University of Hawaii are looking for other options. Dr. Joe DeFrank, who works to find better ways to manage weeds, and Hector Valenzuela, a champion of organic vegetable production in Hawaii, are using a T-STAR research project to work on conditioning farmer's fields for high value vegetable crop production while minimizing damage from hungry insects without sole dependence on insecticides.

In 1996, DeFrank and Valenzuela initiated their T-STAR project to integrate two IPM concepts, trap crops for insect control and living grass sods for weed control. The trap-crop systems they have been developing attempt to provide a desirable mix of plants that attract insect pests as well as beneficial insects. The beneficial insects are tiny wasps that lay eggs in the bodies of immature pests. The pest insect is consumed by the developing wasp that emerges to repeat the process. Their multi-species trap crop houses both the parasites and their hosts, and are located in strategic areas in and around the cash crop, with the trap crop areas more desirable for insects than the cash crop areas.

The melon fly, is a destructive pest of most cucurbit crops in Hawaii. This fly lays eggs in ripe fruits, making them unmarketable. If infested fruits are not properly destroyed, the melon fly population can explode leaving the farmer with little to nothing to harvest. The first step was to identity a community of plants that could attract this fly and, then, screening several melon-type crops to determine in which ones it preferred to lay its eggs. A variety of melon crops exposed to female melon flies. Of the 8 crops screened, yellow and green zucchini were most preferred. Another key step was the identification and growth of a plant community that would attract and sustain melon fly parasites.

USDA entomologists at the Tropical Fruit and Vegetable Research Laboratory in the Manoa Valley were instrumental in helping the UH scientists in detecting habitats of melon fly larval parasites. Drs. Ernest Harris and Renato Bautista, of the USDA laboratory provided technical expertise in the preparation and use of a fruit trap to detect the presence of melon fly larval parasites. The fruit trap consisted of a ripe zucchini squash artificially inoculated with melon fly eggs which were allowed to hatch and grow into 3-day-old larvae. The maggot-riddled fruit was then set out in distinct habitats to determine the presence of larval parasites.

The zucchini fruit trap consisted of zucchini squash that was artificially inoculated with Melon Fly eggs. When maggots appeared the traps were placed in microhabitants where larval parasites could find them and deposit their eggs.

Initial parasite habitat screening was conducted at the UH Pearl City Urban Gardens, located in the heart of Honolulu, and used for a variety of gardening activities . It contains demonstration beds of many different fruit, vegetable, ornamental and native Hawaiian plants. Of the13 microhabitats tested, 3 proved to be hot spots of larval parasite activity. The areas with the highest level of detectable parasites were garden plots containing bitter melon, and experimental termite plots that were devoid of plants but were bordered by wild ivy gourd melon vines located on a nearby fence. Melon fly parasites were detected in abundance only in areas where melon fly activity was high. This work identified bitter melon as

a useful component in a long-term trap crop system.

Adult parasitic wasps do not consume the insects in which they lay their eggs. Sustaining a population of parasitic wasps in a trap crop requires plants that provide their food (nectar and pollen) and shelter. Constructing a community of plants that would both attract and sustain the melon fly and its larval parasite required the right mix of plants.

Habitat plants chosen for this phase of the project included cowpeas (with nectar secreting glands); pollen/nectar producing plants like canola, dill, and several wild flower mixes that contained 10-12 species designed to provide continuous flowering. High sugar content sorghums were included both as windbreak and as a food source for aphids. It has been shown that when aphids feed on certain plants, the positive pressure inside the plant causes them to produce more honeydew and the wasps can feed on these sweet secretions.

The experimental multi-species trap crop system worked. The mix of parasite habitat plants and infested melon fly plants allowed for an explosion in melon fly parasite numbers. This phase of the project demonstrated that parasitic wasps can be attracted and maintained in an artificially constructed habitat when the right mix of food, water, shelter and reproductive potential are provided.

These microhabitants at the Pear City Gardens provided the highest level of dectable Melon Fly larval parasites. The area on the left contained trellised bitter melon. The area on the right was a termite experiment devoid of plants except for wild ivy gourd growing on a fence at the top right of the picture.

Showing pest suppression differences between chemical inputs and living grass sods was demonstrated on a farm on the hot and sunny leeward coast of Oahu in the Waianae Valley. In an on-farm experiment, zucchini squash was grown on conventionally prepared bare ground plots and in a thick stand of chemically-stunted grass. The grass was allowed to grow around the zucchini to provide an in-crop masking effect. Zucchini grown outside of the grassy area was attacked by a variety of insect pests.

In future projects, multi-species trap crops and living grass sods will be combined to determine if control of melon flies can be accomplished with reduced chemical inputs. Trap crop areas will be installed prior to the establishment of the cash crop to obtain a balance of pests and their parasites. Cash crops will be tucked into grassy fields to hide them from searching melon flies. As the melon flies flourish in their nutrient trap crops, a hidden bounty of melon crops will be right next door. ■

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Living sods can make crop areas unattractive to insect pests. In a demonstration plot on a farmer's field in Leeward Oahu zucchini squash growing on bare ground plots were descimated by insects (right side). Zucchini growing in chemically stunted grass were not severly affected.

DAIRY CATTLE
from page 5

insemination represent the next generation of strategies to solve what has been an intractable and costly problem facing dairy farmers in the Caribbean region. ■

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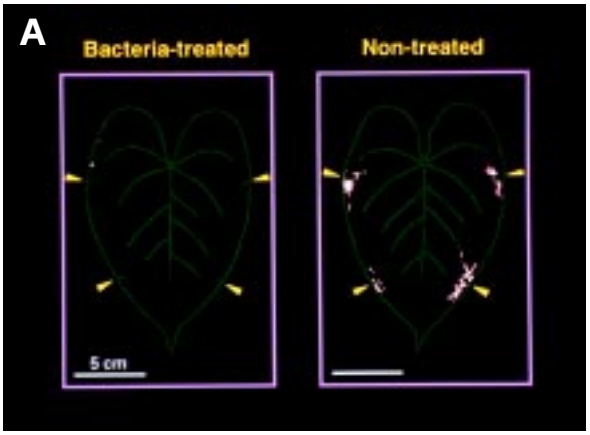
BACTERIAL BLIGHT
from page 1

pesticides do not adequately control the disease or are not environmentally safe. Using strict sanitation that required removal of infected plants, many growers lost more than 50% of their productive plants, and by 1990, many of Hawaii's small growers were forced to abandon anthuriums as a commercial enterprise. The problem was plants often became infected without immediately showing symptoms. Sanitation reduced inoculum levels as well as numbers of plants with visible symptoms, but the symptomless or latent infections were a serious obstacle in attaining lasting disease control. The need for new approaches to halting disease spread were obvious.

The key to combating latent infections of anthurium plants was unexpectedly found while assessing different cultivars for susceptibility. Intrigued by the observation that some cultivars did not succumb rapidly to disease even when inoculated, we collected guttation fluids from several cultivars with different levels of resistance and inoculated them with an antibiotic-resistant strain of *Xcd*, expecting to observe a reduced growth rate of the pathogen in the guttation fluids of resistant cultivars. Contrary to expectation, the pathogen died in all guttation fluids regardless of the cultivar from which they were collected. The killing effect was not observed in filter-sterilized guttation fluids of the same plants, indicating that bacteria or other microbes were responsible for inhibition of *Xcd*. Many leaf-inhabiting bacterial strains naturally found on anthurium were screened and their effects on pathogen growth examined. Interestingly, none of the inhibitory strains was effective alone, but four strains (three non-fluorescing *Pseudomonas* sp. and a gram positive bacterium, possibly *Microbacterium* sp) were highly inhibitory to *Xcd* when used as a mixture. This discovery led to the start of a new T-STAR-funded research project on biological control, based on knowledge of the ecology and epidemiology of this disease.



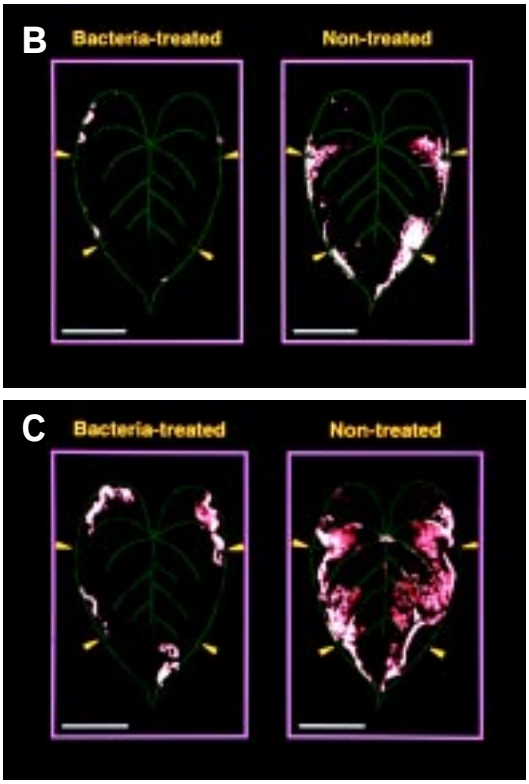
The disease-suppressing effect of the four biological control agents (BCAs) can accurately be evaluated using a genetically-engineered, bioluminescent strain of *Xcd*. This strain converts some of its metabolic energy to photon energy and emits light (bioluminescence), enabling the visualization of the actual infection sites even when symptoms are not expressed. Light emission from infected leaves is detected by exposing the leaves to X-ray films. The autophotographed image was used to measure the movement of the pathogen within the leaves prior to symptom development. This technique was used to determine how the blight pathogen advances in different anthurium cultivars and to test the effects of various chemicals and BCAs on disease control.

The inhibitory effect of BCAs on disease development was striking when applied at high concentrations as a protective measure. BCA's were spray-inoculated onto foliage of a susceptible anthurium cultivar, and the following day, plants were challenged with the bioluminescent *Xcd* strain. Leaves were notched at the margins to provide easy access to the interior of the leaf. The pathogen quickly invaded unprotected leaves, spreading from the wounds to the leaf veins (xylem) and eventually moving down the petiole. In contrast, when leaves were previously treated with BCAs the pathogen did not spread from wounds to the interior of the leaf. Some infection occurred at the leaf margins where xylem endings (hydathodes) provide openings for invasion. This too could be stopped by increasing the concentration of the BCAs initially applied to the leaves. Disease severity was reduced in latently infected anthurium plants showing no symptoms up to 10 days after pathogen inoculation, indicating that the BCAs also have a therapeutic effect. Such disease-suppressing effects by the BCAs were repeatedly confirmed in greenhouse tests. The immediate goal is to achieve the same level of control in the field where the situation is further complicated by the application of pesticides to combat fungal, nematode, and insect problems. For practical control the BCAs must be effective in the presence of commonly used pesticides.

Frequent applications of the BCAs are too costly for commercial application. Disease spread occurs year-around in Hawaii's subtropical climate, and the BCAs must be present at high levels to suppress disease development. They also must survive well on plant surfaces to provide a lasting protective effect. These requirements led to the most intriguing aspect of this research and the discovery that specific nutrients are utilized by the BCAs but not by the pathogen, *Xcd*. Further studies are attempting to enhance survival of the BCAs by repeated applications of specific nutrient (s) to field anthuriums.

Biological control has a history of success when restricted to carefully controlled greenhouse conditions. Greenhouse results, generally, are not transferred easily to the field. Repeated applications of the current bacterial mixtures show promise for control under a semi-protected shadehouse environment where anthuriums are commercially grown in the tropics. The challenge will be to provide a suitable formulation of BCAs as well as cost-effective methods for lasting protection under field conditions. ■

Dr. Ryo Fukui is an Assistant Researcher and Dr. Anne Alvarez is a Professor, both in the Department of Plant Pathology, University of Hawaii at Manoa. Dr. Hisae Fukui is a Researcher and Visiting Scholar from Japan.



*Effect of the biological control agents (BCAs) on progression of leaf infection by the bioluminescent strain of Xanthomonas campestris pv. dieffenbachiae. The BCAs (four different bacterial species) were spray-inoculated onto the foliage one day prior to pathogen inoculation. Leaves were notched at the margin upon inoculation (indicated by arrowheads). Note that infection from the wounds (four notched sites) did not occur in the leaf treated with the BCAs. Infections (white illumination) in the treated leaf started from the hydathode. The images were recorded 14 (**A**), 21 (**B**), and 31 (**C**) days after inoculation.*

PAK CHOI

from page 3

suspended solids and chlorophyll (algae) in the sludge compared to their concentrations in tanks with sludge removed indicated that clarifiers were effective in removing these substances from the system. The ability of the clarifier to remove solids was shown by the much higher concentration of total suspended solids in tanks with solid removal compared to those without. Fish production showed that solids removal increased tilapia production in outdoor tanks without fixed-film biofiltration.

In addition to showing that rearing tank water and sludge provides results at least equal to commercial fertilizers, repeated applications of aquaculture effluents could improve soil fertility by increasing organic matter. As demand for fresh water increases, the aquaculture industry grows intensifying fish farming practices, and disposal of effluents becomes an increasing environmental concern; crop irrigation with nutrient-rich aquaculture effluents - the reuse of water and recycling of nutrients - is an excellent example of sound resource management. ■

Harvest of red tilapia raised in a greenwater tank system with solids removal.

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PAPAYA
from page 2

Papaya can partially compensate for loss of leaves by increasing the photosynthetic rate of the remaining leaf area. Fruit removal does not alter leaf photosynthetic rate. These results indicate that although different cultivars have different responses to artificial defoliation and fruit thinning; the balance between the number of fruit to leaves is the important factor in controlling potential fruit production and final fruit quality.

Sugar accumulation is thought to be controlled by three enzymes in fruit. The activities of these enzymes was studied in papaya to determine which one was crucial for sugar accumulation and hence sweetness in papaya. The predominate enzyme during early fruit growth is sucrose synthase, while sucrose phosphate synthase remained very low throughout fruit growth. Acid invertase, however, is apparently associated with fruit flesh growth and sugar accumulation during last phase of fruit growth. Invertase activity is low in green fruit until four weeks before mature then increases during the period of rapid fruit sugar accumulation. Invertase is therefore the most likely major enzyme contributing to sugar accumulation in papaya fruit. Current research is biochemically characterizing the invertase in the fruit, and cloning the gene. This cloning is essential for the future genetic manipulation of sugar levels in papaya fruit.

This T-STAR project will have achieved its objectives when the gene for invertase has been characterized and its expression during fruit growth confirmed. The availability of this gene will then open the possibility for altering invertase expression during fruit growth and hence fruit sugar accumulation by genetic engineering. ■

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Fat Supplementation can Improve Fertility of Dairy Cows

Charles R. Staples and William W. Thatcher

Nutritional strategies including feeding fish meal containing a potent fatty acid, elcosapentaenoic acid, have been shown to be a possible approach to improving the fertility of dairy cattle in the subtropics and tropics where low fertility is a costly and serious problem.

Poor expression of estrus and low conception rates are major obstacles to successful dairy farming in the tropics and subtropics. Both result in lower fertility and, consequently, less milk production. Nutritional strategies to improve fertility may present a novel approach to this problem. Some long chain, polyunsaturated fatty acids (PUFA), such as linoleic and elcosapentaenoic acids, in the diet may positively influence follicle dynamics and reproductive hormones.

Normally prostaglandin F-2 (PGF_2) is released at the end of an estrous cycle to enable the cow to start another cycle. When a cow is pregnant, a signal is sent to the uterus not to release PGF_2. Suppression of PGF_2 at the time of conception may enhance embryo survival, preventing early embryonic death.

Delivering 0.45 kg/day of yellow grease which contains much more linoleic acid (a PUFA) than tallow to the abomasum of lactating dairy cows stimulated the growth rate and the size of the first dominant follicle much more than delivering tallow alone. In addition, the corpus luteum had a longer life span on the ovary in cows receiving yellow grease with the linoleic acid. Lastly, the uterus released less PGF_2 when yellow grease was present.

Getting PUFA's into the blood is not easy because the PUFA's are changed from unsaturated to saturated fats in the rumen by bacteria resulting in much less PUFA reaching the small intestine for adsorption than would be fed. A fatty acid, elcosapentaenoic acid, unique to fish oils, largely resists the saturation process in the rumen so that a majority of that acid reaches the small intestine in the unsaturated form where it is absorbed and can potentially have a positive effect on fertility. We documented that the oils in fish meal suppress PGF_2 as the yellow grease did; i.e. lactating dairy cows fed menhaden fish meal at 5.4% of diet dry matter released much less PGF_2 into circulation than did cows fed a diet without fish meal.

On two commercial dairy farms 684 cows were used to determine whether menhaden fish meal could improve pregnancy. Two experimental diets were fed as totally mixed rations at each farm. The control and test diets were similar in ingredient and chemical composition except that ruminant grade menhaden fish meal partially replaced blood meal, meat and bone meal, and corn gluten meal in the test diet. Cows were started on the diets between 10 and 33 days postpartum and remained on them until 120 days postpartum. Cows consumed approximately 0.7 kg/day of fish meal (60 g/day of fish oils).

To monitor reproductive performance a targeted reproductive management program was implemented. Data collected support the hypothesis that feeding fish meal influenced the uterine synthesis of PGF_2. This may have contributed to improved pregnancy rates at 120 days postpartum of cows fed fish meal (41.3 vs. 31.9%) at one of the dairy farms. Fertility was not improved at the second dairy. If conception rates could be increased by about 10 percentage units by feeding fish meal, an additional $60,000 might be generated in reduced cull rates on the average 600-cow dairy farm in Florida. ■

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Feeding additional polyunsaturated fats to lactating dairy cows can improve fertility.

The new **T-STAR** website is now on-line! It is located at:
http://www2.ctahr/hawaii.edu/t-star/

The site includes general information about the T-STAR program, the Strategic Plan (which includes Program Goals and Objectives), pages for the ***Caribbean*** and ***Pacific Administrative Groups***, Impact Stories for each, downloadable PDF files (Adobe Acrobat) for several T-STAR Reseach Notes, and a site listing past T-STAR-sponsored Workshops, some of which Proceedings are available. Future additions will include a searchable database for Caribbean Basin abstracts of published papers and a section announcing upcoming Workshops and items of interest. Each ***Basin*** page has links to other sites of tropical and subtropical agricultural interest.

The Website will be up-dated regularly with impact stories and other relevant items as needed. We hope you will find this site a wealth of useful information about the T-STAR program. Questions and comments about the site may be sent to Lynn LeBeck at **lebeck@hawaii.edu**

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