Maui Ag Tech LLC's PESP Strategy

Describe your Organization's Five-Year Goals Related to Pesticide Risk Reduction

Maui Ag Tech LLC is a research subsidiary of Maui Land and Pineapple Company, Inc. located on Maui, Hawaii. Maui Ag Tech's is focused on improvement of the Hawaiian Pineapple Industry through focused basic and applied research programs in collaboration with the Pacific Basin Agriculture Research Center, the University of the Hawaii, the Hawaii State Department of Agriculture, basic registrants, the IR-4 Program, and other pineapple companies in Hawaii.

In 2006, Dole Foods Company, Inc. and Del Monte Fresh Produce (Hawaii) Inc. decided to withdraw from the Pesticide Environmental Stewardship Program. Although my comments are focused on industry concerns, they are primarily focused on issues facing Maui Pineapple Company, Ltd. and growing of Maui Gold on the island of Maui.

The purpose of this memorandum is to present the Five Year Plan for cooperative efforts in the State of Hawaii to reduce pests and pesticide risks in pineapples. The major problems and opportunities are covered in the following sections.

- Tactics 1 and Goals, Natural Flowering Control;
- Tactics 2 and Goals, Methyl Bromide Replacement;
- Tactics 2 and Goals, OP and Carbamate Replacement; and
- Tactics 4 and Goals, Integrated Pest Management.

In the last several years, increasing foreign competition and rising costs has resulted in reduction in total acres planted and annual production in Hawaii. However, solving problems in the smaller pineapple industry is even more critical than in the past. The Hawaiian industry needs solutions to the issues covered in this Strategy to remain as viable economic businesses in Hawaii. Due to the fragile nature of the industry, the decline of pineapple in Hawaii could be very rapid.

The smaller size of the Hawaiian pineapple industry makes it more difficult to register and re-register pesticide active ingredients due to the high cost of registration/re-registration in comparison to the low volume of use in pineapple. The Hawaiian pineapple industry has been fortunate and very grateful for the support received from basic registrants, EPA, and the State of Hawaii to maintain and at times to seek registrations of critical pesticide active ingredients in pineapple.

In the past, major pineapple companies in Hawaii maintained large cooperative and internal research organizations. With diminishing size of the operations, research programs have been one of the first cost reduction measures making it even more difficult to remain competitive. However, major foreign companies continue to invest in research and will become the technology leaders if the collaborative research efforts contained in

the Five Year Plan are not attained on a timely basis. In 2008, an integrated and focused research program described below may provide the solutions to problems that the industry needs to remain competitive.

In recent years, pineapple companies in Hawaii have converted to new hybrid clones such as Maui Gold. The hybrid clones are more susceptible to natural flowering and are more susceptible to slowing of plant growth, plant mortality, yield losses, unpredictable fruit harvests, and reduction in fruit quality due to poor root health caused by a variety of reasons. Plant nutrition, pest risk management and pest control, irrigation management, crop management, postharvest handling, and fruit quality management are different for the hybrid clones than for traditional Smooth Cayenne clones. Applied research programs need to be maintained by the major pineapple companies in Hawaii to commercialize new practices developed in the collaborative research programs.

The major pest/pesticide issues facing the Hawaiian Pineapple Industry include:

Natural Flowering Control

Pineapple is an obligate short day plant when vegetatively mature tends to flower naturally when day length is short (10 hours or less) and night temperatures are cool (65 degrees Fahrenheit or less). The Maui Gold pineapple clone and other hybrid clones grown in Hawaii are more susceptible to natural flowering or precocious fruiting than traditional Smooth Cayenne clones.

Precocious fruiting results in oversupply of fresh Maui Gold pineapples during the July-August period followed by an undersupply of pineapples during the late August to September period. The disruptions in the fruit supply results in low pricing, higher costs, and lost of market share to foreign pineapple growers.

Within the next five years, the Hawaiian Pineapple Industry in cooperation with the collaborative research program will use a phased and integrated approach to solve the precocious fruiting issue in Maui Gold pineapple and other important hybrid clones. The phases of this part of the Strategy are described in Tactics 1 and Goals.

In 2008, Maui Ag Tech may conduct large scale field trials with Retain for natural flowering control. EPA can assist the Industry by approving the registration request for Retain before December 2007. If proven to be cost effective, Retain will provide Hawaii pineapple growers with plant growth regulator to control precocious fruiting in pineapple. The partial control of precocious fruiting using plant growth regulators will provide the industry with the time it requires to develop longer term solutions.

Between 2009 to 2010, transgenic Maui Gold pineapple plants developed at PBARC will be evaluated in field trials to determine natural flowering resistance. Selected transgenic lines will need to be evaluated in yield and adaptation studies, nutritional studies, pest risk management assessments, and fruit quality studies.

If transgenic lines with flowering control have the attributes for commercialization, it will be a company decision proceed towards commercialization.

Based on consumer acceptance, commercialization of new pineapple varieties with natural flowering control may commence by 2012.

Methyl Bromide Replacement

The Maui Gold variety has lower root mass than traditional Smooth Cayenne clones grown for more than 100 years in Hawaii. Due to the nonregenerative nature of the root systems, the roots must be protected from damage by nematode feeding. Other important pest issues affecting root health include the ants-mealybug- mealybug wilt complex, plant diseases such as pineapple heart and root rot, and feeding by soil insects.

The voluntary phase out of methyl bromide in 2005 has reduced treatment options for nematode control for pineapples grown on Maui. Telone II (97.5 % 1,3 dichloropropene) is the primary soil fumigant used in pineapple culture. In areas with drip irrigation systems, nematodes are also controlled with postplant applications of fenamiphos and oxamyl.

Due to presence of alternative hosts during long fallow periods, there are often large carryover population densities of parasitic nematodes. Overall root health in the Maui Gold variety is poor to fair. If root health is not improved, the crop yields, saleable product recovery, and quality that are required to remain competitive will not be attained consistently.

In 2008, Maui Pineapple Company, Ltd. in cooperation with the University of Hawaii will optimize application methods for pre-plant soil chisel applications of 1,3 D for fumigant risk mitigation and improvement in efficacy. EPA - could assist the Hawaiian pineapple industry by providing PESP grants to support the fumigant risk mitigation efforts - in Hawaii.

In 2009, large scale field trials will be conducted to determine if 1,3 D rates can be reduced with the improved application methods for cost control and risk mitigation. Other registered soil fumigants such as Telone EC will be evaluated in parallel with optimization of 1,3 D uses for rate reduction, cost control, and risk mitigation.

Between 2010 to 2012, transgenic Maui Gold plants with resistance to nematodes may be evaluated in field trials to determine their respective commercial potential.

Commercialization of transgenic Maui Gold plants with nematode resistance is outside of the Five Year Plan timeframe. EPA could assist the Hawaiian Pineapple Industry in waiving some of the registration requirements if low volume waivers are appropriate for the new emerging technologies.

OP and Carbamate Pesticide Replacement

During reregistration, minor uses of OPs such as diazinon were limited to make room in the risk cup for major uses. Due to the high cost of completing groundwater monitoring studies, the manufacturing of fenamiphos was phased out by May 2007.

Postplant control of mealybugs and mealybug wilt and nematodes rely heavily on OP and Carbamate pesticides such as diazinon, malathion, fenamiphos, and oxamyl. Without effective postplant control of mealybugs, pineapple growers also risk quarantine intervention since ants and mealybugs are considered as actionable insects. Telone II alone does not guarantee high yields and acceptable product recovery in ratoons, therefore, alternatives must be developed.

Within the next five years, it is imperative to register effective alternatives to diazinon for mealybug control in pineapple and to fenamiphos for postplant nematode control in pineapple.

In 2008-2009, field crop residue studies for Cordon applied as a post plant drip application will be completed by the IR-4 Program. Cordon is being registered as a replacement for fenamiphos. Due to the lower acute toxicity of 1,3 D, risks related to potential occupational exposure to fenamiphos will be reduced. 1,3 D degrades by hydrolysis to chlorallyl alcohol, therefore, potential risks of groundwater contamination will be reduced once existing stocks of fenamiphos are exhausted. Between 2010 to 2012, optimization of drip application methods using enclosed handling systems and development of stewardship programs will be important for risk mitigation.

In 2008, efficacy studies with Movento (spirotentramat) for mealybug control will be conducted by Maui Ag Tech. If effective, a request for conduct of field crop residue trials to support registration of Movento in pineapples will be submitted in 2008 to the IR-4 program. Movento will provide an effective alternative to diazinon.

Once existing stocks of diazinon are exhausted, the registration of alternative 'safer' chemistry will result in a 50 percent reduction in diazinon use in pineapple culture.

The genetic transformation project at PBARC may use coat protein technologies to impart mealybug resistance in the new pineapple varieties. However, unless mealybugs are repelled from the new lines, mealybug control in pineapple will still be critical to prevent quarantine intervention.

Integrated Pest Management

Pineapple growers currently use integrated pest management programs for pest with reliable insect and disease surveys. Survey methods for nematodes, mealybugs, plant diseases, and soil insect pests need to be improved before Integrated Pest Management programs can be practiced effectively in pineapples. Pest pressures on Maui are very high

in comparison to other growing areas due to the small non contiguous field areas surrounded by other areas that may harbor pests.

In many cases, the risks of crop damage and even crop failure are very high in comparison to the costs of the pesticides applied. In some cases, the costs of the surveys are higher than the costs for the relatively low amounts of pesticides applied. However, with urban encroachment, it is important to apply pesticides as infrequently, at the lowest effective rate, and using the best effective alternative to minimize complaints from neighbors and lawsuits. It is also important to reduce pest uses when practical since pesticide risk mitigation provides many benefits.

The preliminary tactics and goals for this part of the strategy are described below. A pest risk management plan based on integrated pest management will be developed after completion of some of the phases for the other elements of the strategy. The pest risk management plan will be provided to the PESP program at a later date.

What do you envision doing (broadly) to try to resolve your major issues?

A phased and integrated approach involving cultural, chemical, traditional plant breeding, and genetic transformation methods will be used to solve the major issues listed above. The phased and integrated approach will use best practical technologies that are technically and economically feasible to control pests and pest problems. The phased and integrated approaches for the major pest issues in pineapples are described below.

Collaborative research programs with the USDA-ARS Pacific Basin Agricultural Research Center, the University of Hawaii, and Inter-Regional 4 Program are being designed to effectively solve pest problems in pineapple culture using focused and integrated research plans. Maui Ag Tech LLC applied research programs are being designed to evaluate new technologies and develop commercial practices programs that not only reduce risks that may be associated with pesticide uses but also make positive economic impacts on the fresh pineapple business.

Resolution of major pest issues in pineapples grown in Hawaii is an iterative process that will rely on attaining project milestones on a timely basis. Time is of the essence. If major issues are not resolved in a timely manner, it may result in the complete demise of the Hawaiian pineapple.

The primary goal of the Five Year Plan is to address the issues of primary concern. Resolution of the issues of primary concern will increase crop yields, increase saleable product recovery per acre, improve on the predictability of fruit harvests, and improve fruit quality while reducing risks that may be associated with pesticide uses in pineapple. Reduction in pesticide use and associated risk is good business since it reduces costs, protects the human health and the environment, and reduces potential future liabilities.

Goal 1 and Tactics

Natural Flowering Control

Natural flowering control is the most important limiting factor affecting the economic viability of the Hawaiian Pineapple Industry. The first goal uses an integrated and phased approach for control of natural flowering in Maui Gold pineapples and other hybrid clones.

The objective of natural flowering control will be to initially reduce natural flowering to not more than 20 percent in susceptible field areas using cultural methods and plant growth regulators followed by complete elimination or minimization of natural flowering using genetic transformation methods.

The success of this goal can be measured using field surveys such as forcing efficiencies and One Time Bud Counts. The success of this goal can also be measured by comparing harvest distribution and deliveries from susceptible areas subjected to the new technologies with historical records. Use of segmented gene technologies during genetic transformation events may also lead to development of pineapple varieties that are resistance to parasitic nematodes and/or mealybug wilt.

The first phase of natural flowering control consists of planting of good planting material in the proper growing environments followed by maintenance of vigorous, rapid plant growth. Optimization of pest control practices under Methyl Bromide Replacement and OP and Carbamate Pesticide Replacement will be key components of the overall strategy for natural flowering control. Under current circumstances, Maui Gold pineapple plants must attain target plant or fruiting sucker weights at proper plant age to minimize the negative impacts of natural flowering. It is important to induce flowering with ethylene gas in plant crops as scheduled in crop management programs to minimize the number of acres that may be impacted by natural flowering.

The second phase consists of large scale evaluation of Retain for natural flowering control. Retain ({IS}-trans-2-Amino-4-(aminoethoxy0-3-butenoic acid hydrochloride, EPA Reg. No. 73049-45) may be effective for control of natural flowering in pineapple. Maui Ag Tech will evaluate Retain in large scale trials for flowering control in pineapple in 2007-2008 after approval of the registration package by EPA. EPA can facilitate implementation of this phase of the PESP strategy by approving the registration package for Retain within the next 90 days. The applied research will be conducted by Maui Ag Tech LLC in field areas that may be highly susceptible to natural flowering.

The goal of the second phase of this activity is to provide pineapple growers with an interim solution to natural flowering management as longer term solutions are developed. Hopefully, the second phase will provide a technically and economically viable practice for at least the next ten years. The ultimate measurement is to avoid disruptions in the fruit supply that have plagued pineapple production since the conversion to the new hybrid clones.

The third phase of natural flowering is to first develop a robust genetic transformation method for pineapples followed by agrobacterium transformation using the 355 promoter and anti-sense ACC synthetase gene delivered with segmented gene technologies. The development of the robust transformation system and subsequent genetic transformation work will be completed by PBARC. Selection of putative transgenic plants will be accomplished using standard laboratory methods. Greenhouse and field screening of selected transgenic plants will be completed by the Hawaiian Pineapple Industry in collaboration with the University of Hawaii. The goal of the third phase is to develop potential commercially viable varieties that will be accepted by the consumers.

The development and commercialization phases of the genetic transformation program will be provided to EPA as an amendment to this PESP Strategy at a later date. EPA can assist pineapple growers by maintaining the exemption from tolerances for the ACC synthetase gene and coat protein gene.

Goal 2 and Tactics

Methyl Bromide Replacement

Feeding of parasitic nematodes on pineapple roots may lead to crop yield losses, reduction in saleable product recovery per acre, and disruptions in the fruit supply or crop failure when nematodes are not controlled.

Of the five parasitic nematode species found in pineapple culture in Hawaii, the reniform (*Rotylenchulus reniformis* Linford) and the root knot nematode (*Meloididyne javanica*) are of major economic importance. Maintenance of healthy root systems is critical for uptake of soil nutrients and soil moisture and for anchorage of the plants. Plant stresses caused by poor root systems such as less than optimal leaf nitrogen levels or moisture stress may lead to increased potential for natural flowering.

In 2005, Maui Pineapple Company voluntarily stopped the use of methyl bromide to support protection of the ozone layer. Methyl bromide when applied correctly was more effective than Telone I1 in controlling parasitic nematodes in pineapple culture. It is important for pineapple growers to optimize practices and application of registered pesticides for pest control and risk mitigation. Due to high development costs, new nematicides may not be available to minor crops like pineapple in the future. Some of the current alternatives are not consistently effective or are too costly to be economically sustainable practices.

The objectives of this goal are to optimize the effectiveness of cultural practices and registered products for nematode control.

The success of this goal can be measured by monitoring of nematode population dynamics as influenced by previous and optimized practices. The success of this goal can

also be measured by improvement in root health of Maui Gold and the associated yield, product recovery, and fruit quality benefits that will be realized.

Risk mitigation can be measured by reduction in fenamiphos use (outside of the five year plan period), reduction in 1,3 D use in pineapple, or reduction in potential occupational and residential exposure to 1,3 D due to agricultural uses for pineapples grown on Maui.

The first phase will be to improve starvation and desiccation of nematodes during inter-cycle periods. Cultural practices involve the use of a long clean fallow period to reduce carry over nematode infestations.

However, it is difficult to maintain weed free conditions in high rainfall areas thus providing alternative hosts for nematodes. Cover crops have been evaluated in the past, however, they did not prove to be a practical solution to minimizing carry over nematode population densities due to the high costs of additional land preparation, seeding, irrigation, and fertilization to maintain viable cover crops. In some cases, the cover crop became a serious weed problem in the subsequent cycle. Various methods such as use of registered herbicides of eliminating alternative hosts during the fallow period will be evaluated.

The second phase will optimize application methods for registered soil fumigants with emphasis on preplant soil chisel injection methods of 1,3 D. Optimization of the methods will increase the zone of control, rate reduction, and fumigant risk mitigation. In parallel with this phase, nematode population dynamic studies will be conducted in collaboration with the University of Hawaii to establish economic threshold levels for integrated pest management programs and screening of new technologies in subsequent phases.

The third phase will be to first develop and select transgenic pineapple plants using Agrobacterium transformation with root specific promoters and additive proteinase inhibitors. The selected transgenic pineapple plants with nematode resistance will be evaluated in small scale field trials over several cycles to measure the long term effectiveness of the technology. If commercialized, transgenic pineapple plants with nematode resistance may result in reduction or elimination of 1,3 D and/or carbamate uses (oxamyl) for nematode control in pineapple. Potential risks that may be associated with fumigant, OP, and carbamate uses for nematode control may be significantly reduced if transgenic pineapple plants with nematode resistance exhibit long term effectiveness.

The development and commercialization phases of the genetic transformation program will be reported to EPA as an amendment to this PESP Strategy at a later date. EPA can assist in achieving this goal by providing registration requirements for the new technologies and if scientifically justified to reduce registration requirements based on site specific use patterns.

Goal 3 and Tactics

OP and Carbamate Pesticide Replacement

Control of the ant-mealybug-mealybug wilt complex is one of the most important factors to maintain good root health. Ants tend mealybugs, protect them from predators, and clean up secreted honeydew. The response to feeding of large mealybug colonies results the destruction of the root systems resulting in mealybug wilt.

Of the eight mealybug species found in pineapple, the grey mealybug and pink mealybug are of major economic importance. Pink mealybugs feed on the lower portions of the pineapple plant and the pineapple roots, therefore, they are very difficult to control.

The Hawaiian Pineapple Industry relies heavily on OP and carbamate pesticides for control of mealybugs and nematodes. Due in part to the transition that the Hawaiian Pineapple Industry has gone through in recent years, there is no new registrations of 'safer' chemistry that are effective for mealybug control and postplant nematode control.

The ant-mealybug-mealybug wilt complex cannot be controlled with the new application restrictions on diazinon use in pineapple. After existing fenamiphos stocks are exhausted, it will be imperative to register an effective alternative to minimize risks due to accelerated microbial degradation of OP and Carbamates in tropical soils. Under current conditions, pre-plant 1,3 D applications alone are not adequate to protect pineapple roots throughout the entire cycle making it important to manage nematode population densities with postplant nematicide applications.

The objectives of this goal is to use cultural practices for mealybug wilt control and registration of new efforts to provide long term solutions to mealybug-mealybug wilt and postplant nematode control.

The success of this goal can be measured by reduction in carryover and infield infestations of mealybugs, elimination of mealybug wilt from pineapple fields on Maui, registration of effective alternatives to diazinon and fenamiphos, and improvements in crop yields, saleable product recovery per acre, and fruit quality.

The risk mitigation benefits of this goal can be measured by the reduction in the pounds of OPs (diazinon, fenamiphos) applied in pineapple after alternatives are registered.

The first phase will be to evaluate carryover infestations of mealybugs in the pineapple trash and on pineapple planting material. Cultural practices such as improved knockdown and plowing of the pineapple trash to reduce carry over infestations will be evaluated. A preharvest insecticide spray may be necessary to reduce mealybugs carried to the fields with planting materials. If 'safer' chemistry can be identified for application as pre-plant dip treatments, it will be evaluated and registered. Rouging of plants affected by mealybug wilt will also help to prevent the spread of mealybug wilt and planting material with high potential to develop mealybug wilt.

The second phase will be to complete field crop residue studies for Movento for mealybug control and Telone EC for postplant nematode control. The Telone EC field crop study in cooperation with the IR-4 Program and Dow AgroSciences has been started. Completion of the field crop residue study is expected by March 2009. The registration package should be submitted to EPA for review by the end of 2009. EPA can assist in accomplishing this goal by accelerating the tolerance petition and registration package review for postplant use of Telone EC in pineapples.

Efficacy studies evaluating Movento for grey and pink mealybug control are underway on Maui. A registration request will be submitted to IR-4 by mid-year next year. If the registration request is approved, Movento field crop residue studies should be started in 2009. It will take about two years to complete the field crop residue study. The tolerance petition and registration package may be submitted to EPA in 2010. EPA can assist in achieving this goal by accelerating the review of the tolerance petition and registration package of Movento.

The third phase will be to develop commercial practices programs, implement use of the newly registered products, and optimize the efficacy through improvements in application methods, rate and timing of applications, and integrated pest management programs.

Screening of new chemistry must continue for pest control needs. As uses of older chemistry diminish, they may no longer be available to pineapple growers due to the low volume of use in Hawaii.

The fourth phase will be to strengthen pest control programs with integrated pest management programs using the tools that will be available to the pineapple industry. Transgenic pineapple plants based on coat protein technologies may be developed in the genetic transformation program at PBARC.

Goal 4 and Tactics

Integrated Pest Management

A pest risk management plan for pineapples grown on Maui will be developed to identify challenges and opportunities to implement Integrated Pest Management Programs. As previously stated the accuracy and representativeness of the insect and disease surveys will need to be improved prior to Integrated Pest Management implementation. Pest control options and current practices need to be optimized.

The objectives of this goal will to implement precision farming to pineapple grown on Maui. The precision farming will result in reduction in pesticide uses and potential risks associated with pesticide uses.

The success of this goal can be measured by the reduction in the pounds of pesticides, reduction in associated materials and supplies and application costs, and reduction in human health and environmental risks associated with pesticide uses.

One of the opportunities will be to develop pheremone attractants for lepodopteran pests of Maui Gold and other hybrid clones. The phernomes in combination with insecticides in traps may be an effective means of reducing pest populations.

Mealybug population levels can be reduced by parasitoids identified in previous biological control programs. A cost benefit analysis of rearing parasitoids will be conducted. Mealybug control is not a national priority, therefore, it will be difficult to secure Federal funding to sustain an insect rearing and release program in pineapples.

The Hawaii Department of Agriculture is funding a study to evaluate new ant bait formations for Little Fire Ant Control. The Little Fire Ant is a quarantine pest that has not been observed on Maui. However, the new ant baits screened in this study may be effective for control of big headed ants and other ant species found in pineapple fields. This will provide another opportunity to reduce pesticide uses for direct mealybug control.

The timeline and milestones for this goal will be provided to the PESP at a later date.