Environment-Friendly Strategies for Management of Mealybugs, Ants, Ampeloviruses, and Mealybug wilt of pineapple.

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Hawaii
September 1, 2006 to August 31, 2008
$40,000

NONTECHNICAL SUMMARY: Pineapples are the State of Hawaii's leading agricultural commodity. One of the most economically important insect pests of pineapple are pineapple mealybugs. The mealybugs are vectors of at least three Pineapple mealybug wilt associated viruses (PMWaV). PMWaV infections correlate with yield reductions that can exceed 35% in pineapple. Also, PMWaV-2, is a factor in mealybug wilt of pineapple (MWP), one of the most devastating diseases of pineapple in Hawaii and worldwide. Historically, the pineapple industry has been the largest user of the restricted organophosphate insecticide, diazinon, in Hawaii. Although ants are not a vector of PMWaVs, we previously found that the use of Amdro® Pro ant bait applied as a broadcast or in bait stations in the pineapple plantings correlated with reductions in the spread of PMWaVs in the pineapple plant crop and that ant bait delivered in bait stations provided longer periods of control than broadcast applications. Furthermore, diazinon applications were not needed until shortly before harvest if ants were controlled. We conducted a similar field study presented here, to evaluate alternative, environmental-friendly approaches to control grey pineapple mealybugs (GPM), associated ant species, the spread of the PMWaVs, and subsequent MWP in the pineapple ratoon crop. The infrastructure of the pineapple field and canopy becomes more complex in the ratoon crop cycle. The results from this study showed that PMWaVs were spread in the ratoon crop by grey pineapple mealybugs in the absence of ants, regardless of ant bait application or method of delivery. When mealybugs were tended by ants, the time period until ants tending the mealybugs were controlled impacted the number of new virus infections detected. The more rapidly the ants were eliminated the less virus incidence increased. Thus, in the case of the ratoon crops, broadcast applications of ant bait clearly provide more rapid control than bait station applications for BHA. Ants were eliminated more rapidly in the fallow period by in-field broadcast applications of ant bait than by peripheral applications in bait stations. The pineapple industry of Hawaii currently includes ant control as a component in and integrated pest management approach to controlling and minimizing mealybugs, viruses, ants, and mealybug wilt of pineapple.

INTRODUCTION. Pineapples are the State of Hawaii's leading agricultural commodity, covering nearly 14,000 acres and employing over 1,100 full time employees. Value to the State of Hawaii is about $75,542,000. Pineapple is a densely planted crop (58,600-75,000 plants/ha) grown year-round in Hawaii. A complex of mealybug transmitted Pineapple mealybug wilt associated viruses (PMWaV) have been identified in pineapple. These viruses correlate with yield reductions that can exceed 35% in pineapple. In addition, PMWaV-2, is a factor in mealybug wilt of pineapple (MWP), one of the most devastating diseases of pineapple in Hawaii and worldwide. Pineapple is vegetatively propagated and thus, virus infected propagation material perpetuates the yield reductions and the MWP problems. The most economically

important insect pest of pineapple is the grey pineapple mealybug (GPM). GPM is a vector of the PMWaVs and GPM feeding is a contributory factor in MWP. Currently, over 95% of the foliar insecticide applications, namely diazinon, applied by the pineapple industry is targeted at mealybugs and reducing MWP and virus spread. Diazinon, an organophosphate insecticide, has long residual effects in the environment. Birds and beneficial insects such as pollinators and parasitoid wasps are highly susceptible to this compound. Mealybugs are blown in or transported on planting material and usually do not establish large colonies in the absence of ants. However, when ants are present, mealybug colonies thrive. Ants consume the honeydew of the mealybugs, transport them, and protect them from natural enemies and biological control agents. Amdro® Pro ant bait which contains hydramethylnon, was approved for in-field use in pineapple in 2003. The material is applied in a grit formulation and does not bioaccumulate in the environment and is nonsystemic in plants and fruit. It is not expected to be toxic to fish in the natural environment due to its low water solubility and rapid degradation in sunlight. Because Amdro® is applied as a bait formulation it does not have the liquid aerosol drift risks of diazinon. In addition, special devices have allowed the pineapple industry to apply Amdro® in areas near waterways or residential areas without risking untargeted exposure. Amdro® Pro ant bait compatibility with biological control agents for mealybugs and the recent approval of broadcast application in pineapple potentially provides an alternative to overhead diazinon application applied to control virus spread and MWP. Amdro® Pro is not without disadvantages. It is susceptible to moisture or light, which renders it ineffectual within 24 hours. Thus timing and method of application are important factors. And, Amdro® Pro does not directly control mealybugs.

The use of ant and mealybug detection systems combined with in-field ant control had promising results in the plant crop for preventing the spread of PMWaVs by grey mealybugs and the development of MWP. Amdro® Pro ant bait was effective at reducing ants in pineapple fields and indirectly reducing mealybugs and virus spread in the plant crop of pineapple. Bait stations were modified to alleviate the moisture and light susceptibility problems and further reduce amount of product applied while extending the protection to several months. However, the infrastructure of the pineapple field and canopy becomes more complex during the ratoon crop. This potentially affects foraging patterns of the ants and mealybug population development and thus, control methodologies may require change. The focus of this study was to evaluate the efficiencies and capabilities of ant and mealybug detection and ant control methodologies on the 1) prevention or reduction of virus spread, 2) prevention or reduction of MWP, and 3) replacement of diazinon applications, in the ratoon crop.

OBJECTIVE: Demonstrate and compare alternative control strategies for minimizing incidences of virus spread and mealybug wilt of pineapple in the ratoon and fallow periods of the pineapple crop.

A field demonstration and comparison of alternate control strategies that included the use of pest detection and pest-based timing of Amdro Pro ant bait applications as a broadcast or in bait stations was completed for the ratoon crop. The demonstration during the fallow period consisted of only peripheral broadcast applications or in-field broadcast application of Amdro® Pro because of a plantation issue that developed that was external to this study and the collaborative agreement.

APPROACH. An experimental design with three treatments and three replicates was established in a 94 acre site on a pineapple plantation in Hawaii immediately after plant crop fruit harvest. Ant bait treatments consisted of 1) calendar-timed Amdro® Pro broadcast applications at weeks 16 and 36 after plant crop fruit harvest, and 2) broadcast, or 3) bait station applications applied when ants were detected with ant attractants. Diazinon had been applied just prior to plant crop fruit harvest by the plantation. PMWaV infections were accessed initially when infestations were first detected and after control was achieved. Control was defined as the time when less than 2 ants were detected with attractants in the treated region. Application of ant bait was based on detection of ants during bimonthly visually inspections and with ant attractants. At two-week intervals, sugar-honey-based ant attractants were placed at 100' increments throughout the treatment plots and left in place for 48 hours. Attractants were collected and ant species were identified and counted. Changes in virus incidence and pattern of spread was monitored by mapping and virus assaying plants in each ant infestation that were in three types of areas; 1) no visible signs of mealybugs, 2) mealybugs not tended by ants, and 3) mealybugs tended by ants. For each type of area, 100 plants were sampled when the pest was initially located and again several weeks after control or the end of the study, when appropriate. The PMWaV status of each mapped plant was evaluated with monoclonal antibodies specific for PMWaV-1 and PMWaV-2, in tissue blot immunoassays. Treatment comparisons included a) time until big-headed ants (BHA) were controlled, and b) increases in virus incidence between regions infested with mealybugs not tended by ants, regions infested with mealybugs tended by BHA and regions that did not appear infested with mealybugs. Strategy demonstrations and results were shared with the pineapple industry and interested professionals and researchers.

RESULTS. The results of our study showed that the in-field use of Amdro® Pro ant bait in pineapple fields correlated with reductions in the spread of Pineapple mealybug wilt associated viruses (PMWaV)s in the ratoon crop cycle of pineapple. Although PMWaVs can be spread by mealybugs in the absence of ants, the presence of ants tending mealybugs correlated with greater increases in virus incidence. The incidence of virus infected plants increased 1-2% in regions with GPM that were not tended by ants, regardless of the treatment plot. When GPM were tended by ants, incidence increased 2% ± 1% with pest-timed broadcast applications, regardless of the age of the ratoon crop. Plots treated with bait stations had virus incidence increases of 4% ± 2% and 10% ± 2% in the first and second six months of the ratoon, respectively. Ant control with calender-based broadcast applications of ant bait applied at weeks 16 and 36 resulted in 6% ± 2% and 7% ± 3% increases in virus incidence when mealybugs were tended by ants in the first and second six months of the ratoon crop, respectively. Ants were eliminated more rapidly in the fallow period by in-field broadcast applications of ant bait than by peripheral applications in bait stations.

Interestingly, the most effective control strategies differed between the ratoon crop and the preceding plant crop. Bait stations required substantially longer periods of time to achieve and control compared to broadcast applications of ant bait during the ratoon crop. Second, the continued presence of bait stations in the field failed to prevent new or re-infestations during the ratoon crop. In general, control of ants with bait stations required longer periods of time as the ratoon crop aged and the longer the time period required to eliminate the ants the greater the increase in virus incidence. The early detection of ants was a critical component in the temporal and spatial placement of ant bait. Amdro® Pro ant bait, unlike diazinon, requires weeks or

months to control the target pest, thus early detection of the pest and timely application of control were critical for preventing build up of GPMs and the spread of PMWaVs.

IMPACTS.

The application of diazinon, an organophophate insecticide, during the growth stage of the pineapple plant crop was eliminated without increase in virus incidence if ants were controlled. The in-field use of Amdro® Pro ant bait in pineapple fields correlated with reductions in the spread of Pineapple mealybug wilt associated viruses (PMWaVs) in the plant and ratoon crop cycles of pineapple. This knowledge has lead to the development of IPM strategies that incorporate ant control as a component for disease and virus management in pineapple by the plantations in Hawaii.

Safeguarding human health and the environment. The adoption of pest control alternatives such as ant bait by the pineapple growers in Hawaii can help to reduce the use of the organophosphate diazinon. The elimination of a single spray for each plant crop field reduces the risks associated with drift and non-target organisms. Because pineapple is grown worldwide and is often imported into the US from other countries, the adoption of lower risk or lower impact strategies can provide global benefits. A reduction in diazinon application during the growth stage of the pineapple plant crops on a world wide basis represents thousands of pounds of organophosphate not used. The replacement of one chemical with another is less than ideal, but the ant bait evaluated in this study has lower risk factors such as lack of biomagnification, lack of aerosol drift, and lack of harm to beneficial insects, pollinators, and natural enemies than diazinon. Ant bait has its limitations, however. It is not a replacement for diazinon and, although ant bait contributes significantly to the reduction of mealybugs, most notably in the pineapple plant crop, mealybugs can and do build up during fruit maturation, resulting in diazinon applications during these stages.

Economic benfits. The outcomes resulting from this study and demonstration of the applied knowledge were shared with pineapple growers, researchers, and professionals responsible for pineapple production worldwide. Virus detection techniques and hands-on training were provided as a component of this project to researchers and pineapple professionals both locally and worldwide. As a result, the incidences of PMWaVs can be determined in the US and other countries around the world. These viruses may be of great importance to import/export regulators and customs officials overseeing the movement of planting material worldwide. The incorporation of ant control into the pineapple IPM program will reduce the grey pineapple mealybug populations and spread of viruses in pineapple by mealybugs tended by ants. As a result, the chances of mealybug wilt are reduced, fruit quality is improved as a result of the reduction of mealybugs, early applications of diazinon could be eliminated, and additional yield loss associated with PMWaV- infection can be minimized improving profits.

Implementation of IPM. Ant control which was the main focus of this study, and the use of the different bait delivery methods, have already been adopted by the pineapple industry in Hawaii as an important part of the current management strategies for the control of ants, and subsequently, mealybugs, virus spread, and mealybug wilt of pineapple. The incorporation of ant control will reduce the grey pineapple mealybug populations and spread of viruses in pineapple by mealybugs tended by ants. Industry, however, still needs an alternative for diazinon that can be used on mature fruit prior to fruit harvest. Mealybugs can still be a serious problem on fruit, lowering fruit quality for fresh fruit sales.

Collaboration and stakeholder interest. The use of pest detection as a means of timing ant control applications was shown to be superior to calendar-based applications, both in control efficiency and amount of product used. However, the labor costs involved in provisioning, distributing, and checking pest detection units limits their use and acceptance by plantations. As a result of this study and conversations with the pineapple industry about the findings, the possibility of adapting alternative pest monitoring methods such as automated remote biosensing as a component of pineapple IPM programs may be the next step in improving control efficiencies while keeping labor costs down. In addition, growers from Malaysia and Philippines have shown interest in incorporating ant control into their own pineapple production programs.

Publications (only those not previously reported)

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