AREA-WIDE CONTROL OF THE ORIENTAL FRUIT FLY AND MELON FLY IN TAIWAN

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ABSTRACT

Area-wide control have been tested for the oriental fruit fly (Bactrocera dorsalis Hendel, OFF) and melon fly (Bactrocera cucurbitae Coquillett) in Taiwan. The control tactics depend mainly on methyl eugenol, Cuelure, and protein bait containing spinosad. The non-chemical efforts are concentrated on (1) organizing involved farmers, (2) establishing geological information, (3) monitoring fruit fly density, (4) establishing fruit production information, (5) holding training programs, and (6) maintaining the orchard sanitation. Area-wide OFF control had been tested from year 2000 to 2005 in 21 districts, and the results indicated that farmers with common interest, mainly in a monocropping system, will cooperate better than those planting multiple crops. The Taitung area in Taiwan presented a fruitful result due to sugar apple, Annona squamosa L., that constituted 95% of its fruit production, and OFF density ratio monitored in inner quarter, buffer zone, and outskirt was 1: 10: 30-100. Within three years, control acreage in Taitung has expanded from 4000 ha to 10,000 ha and then to 15,000 ha. Although GIS/GPS technologies have been used in density monitoring and control strategy planning, 3-dimensional aerial photo have gained stronger acceptance from the local farmers. The 3-D digital displayed system creates a “virtual reality” of targeted areas onscreen which ignites farmers’ interest because they can overlook their own orchards and the whole control area. Bringing farmers from the whole area into a conference room has inspired enthusiastic participation in the ongoing area-wide control program, providing updated pest density data which also give farmers motivation to plan their work, and where more details on control strategy could be discussed.

Key words: Area-wide control, Bactrocera dorsalis, Bactrocera cucurbitae

INTRODUCTION

The fruit fly control project in Taiwan was improved by (1) establishing an island-wide 10-day interval fruit fly density monitoring system since 1994, (2) controlling the quality of the lure, and (3) testing better field application strategies. By suggesting correct suppression measures for farmers, the oriental fruit fly population has been suppressed to a level of 15% of pre-control density. These efforts were supported by the funding from government for purchasing 40 tons methyl eugenol (ME) per year, and then manufacturing more than two million ME fiberboard baits to cover 150,000 ha orchards. Fruit crops protected are mango, wax apple, citrus, guava, peach, pear, sugar apple, Carambola, etc. (Cheng et al., 2003). In this project, we continuously exchange ideas with the Hawaiian fruit fly control working team. The new approaches applied in the area-wide control strategies include the improvement of ME baits, incorporation of new traps and protein bait, GF-120 (Vargas et al. 2000; Cheng et al. 2005). We successfully organized 155 farmer associations to synchronize the fruit fly control project. However, numerous technology developed in recent years have been incorporated into the program (Vargas et al. 2000), particularly, the GEO information as well as computerized data processing in pest monitoring and damage assessment (Deutsch and Journel 1992; Mau et al. 2003).
MATERIALS AND METHODS

1. Attractants and baits used: methyl eugenol, Cuelure, GF-120, and other protein baits.
2. Test insects: oriental fruit fly and melon fly.
3. Traps: improved trap using fiber board/cloth was designed, which can periodically reload fresh ME bait mixture.
4. Monitoring trap: the pheromone trap for Spodoptera exigua has been used.
5. Poisoned baits: 95% Naled mixed with insect attractants (methyl eugenol or Cuelure) at the ratio of 5 to 95.
6. Forecasting model construction and analysis of population change rate.
7. New software for GIS/GPS systems.
8. Aerial photos combining with the 3-dimensional digital display software.

RESULTS AND DISCUSSION

Establishment of Area-wide Fruit Fly Control Districts

With the cooperation of the Hawaiian fruit fly working team, the official fruit fly control program sponsored by the Bureau of Animal and Plant Health Inspection and Quarantine (BAPHIQ), this area-wide (AW) control program has progressed rapidly, particularly on the establishment and extension of AW control strategy. For example, starting 2002 after an intensive field survey and discussion with the farmers and staff of the Taitung Farmer Association, the OFF density monitoring was initiated for their AW control district. Taitung is the first area where AW control district was established, initially covering an area of 4,000 ha, and then expanded to 15,000 ha in 2005. The frontier, the buffer zone and the inner circle were established, and each had its own density data to realize the fruit fly invasion from the western mountainous side. The frontier, buffer zone, and the inner circle had a fruit fly density gradient of 30-100: 10:1, and the fruit fly damage in Taitung has been minimized in sugar apple (Fig. 1).

The active “search and destroy” monitoring tactic has also been tested since 2002, in another 15 control districts covering a total of more than 10,000 ha in the west coast (Fig. 2). Among these areas, a few AW districts have gained satisfactory results with outer and inner OFF density difference exceeding 20 times. However, other AW districts were still not able to reach the first stage implementation target, i.e., a difference of 3-10 times. Four new districts have been established in 2005. The first one is Hua-lien control district located 100 km north to Taitung. Even in the first year of OFF control, the farmers in Hua-lien have already gained satisfactory result in Pomelo production. Three other new control districts are the Da-lin, Mei-sun, and Chun-nan districts of Chia-yi county in southern Taiwan. Total acreage of these three districts did not exceed 1,000 ha, however, the OFF control results have exceeded previously established districts in west coast. The main reason for this success is the incorporation of 3-D aerial photo digital system in the meeting for planning and designing the control strategy with the farmers. This new technology has been considered as a breakthrough to our previous belief that the AW control area should be as large as possible, and could not succeed in a small area. Through detailed discussion and planning, and with the help of 3-D aerial photo illustration, farmers of these small control districts were inspired to become more enthusiastic and were willing to get more involved in OFF control details (Fig. 3).

Farmer Education Sessions

Farmer education program has been continued. The cage for demonstrating the actions of ME and Cuelure on FF and MF has resulted in very convincing visual confirmation of the bait’s action to farmers, and has become an essential part in the farmer’s education session. The 3-D aerial photo display also offers great help in farmer education sessions.

Application of Protein Baits

Protein hydrolysate application method has been improved by adding borax and sodium hydroxide to increase the pH value, which increased the ammonia component of food bait and resulted in better trapping effect. Procedures for blending the mixture is well illustrated in a pamphlet and dispatched to 155 farmer associations. With the help of Dr.
Fig. 1. Oriental fruit fly density monitored in Taitung AW control district in Dec. 2003 (innermost: green spot; inner: blue spot; outer: red spot).

Fig. 2. Sixteen OFF AW control districts have been established in Taiwan in 2002-2006.
Fig. 3. The newly established AW control district, Juan-Nan village, shown in the 3-D digital display system.

Fig. 4. Field demonstration and discussion on the application of GF-120 on trap crops.
Ronald Mau and the Dow Chemicals, the new protein bait, GF-120, has been successfully introduced to Taiwan in 2003 and gained an approval with the common name of spinosad 0.02% bait concentrate to be used on guava; official demonstration program for GF-120 were started in 2005. Two demonstration orchards have applied GF-120 and were compared with the traditional protein baits for education and extension purposes.

GF-120 was also introduced to several districts that produce loofah, melon, and cantaloupe for melon fly control (Fig. 4) especially during spring to summer. This useful material will be helpful in reducing the female fly density and preventing OFF outbreak as well as minimizing the environmental hazard of chemical insecticides.

**Field Sanitation**

Improvement of field sanitation was conducted in the three newly established OFF control districts in Chia-yi County in 2005 (Fig. 5). By combining bagging, male annihilation, GF-120 and field sanitation with only 2.2% increase in control cost, excellent quality wax apple was harvested in Juan-Nan village and for the first time, 20 tons of wax apple have been exported. Total net income increase was 100,000 US dollars for that crop season (Table 1).

In the Da-Lin village, male annihilation, GF-120, and field sanitation were adopted in the 140 ha citrus groves. This is the first time that farmers did not use any pesticide for controlling the fruit flies, and saved 94.5% control cost in 2005 (Table 2).

In 2006, field trials on sanitation were tested in bitter gourd in central Taiwan. The farmers in Pei-tou area produce bitter gourd without bagging and have suffered great loss due to melon fly infestation for many years. Simply by applying methyl eugenol, spraying GF-120 on the trap crops inside and outside of their orchards, and implementing field sanitation, the damage rate decreased from 70% in 2005 to 15% damage in 2006 (Fig. 6). After the demonstration session held in July 12, 2006, many growers from other farmer’s associations became interested in adopting this AW control scheme and would start their own field trial on bitter gourd as well as Loofah.

**Issuing the OFF Newsletter Every 10 days**

The island-wide OFF monitoring network continuously provides population census data, which enables the working team to analyze OFF population dynamics and to construct the forecasting model. These analytical works prove to be useful in identifying high-density location
Table 1. Fruit production and pest control cost for wax apple in Juan-Nan village (200 ha)

<table>
<thead>
<tr>
<th></th>
<th>2005 /</th>
<th>2004 /</th>
<th>± %</th>
<th>Net(US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit Production:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (tons)</td>
<td>545</td>
<td>857</td>
<td>-36%*</td>
<td></td>
</tr>
<tr>
<td>Price (US$/kg)</td>
<td>3.10</td>
<td>1.85</td>
<td>+66%</td>
<td></td>
</tr>
<tr>
<td>Value (million US$)</td>
<td>1.68</td>
<td>1.58</td>
<td>+6%</td>
<td>+100,000</td>
</tr>
<tr>
<td>Export (tons)</td>
<td>20**</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pest control cost (US$):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bagging</td>
<td>184,615</td>
<td>184,615</td>
<td>+2.2%</td>
<td>-4,000</td>
</tr>
<tr>
<td>Male annihilation/ME</td>
<td>3,000</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food bait/GF-120</td>
<td>100</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanitation</td>
<td>900</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Production reduced by 25% due to typhoon.
** First time ever, no pesticide application and also no residual hazard.

Table 2. Fruit production and pest control cost for citrus in Da-Lin village (140 ha)

<table>
<thead>
<tr>
<th></th>
<th>2005 /</th>
<th>2004 /</th>
<th>± %</th>
<th>Net(US$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit Production:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (tons)</td>
<td>1,200</td>
<td>1,595</td>
<td>-25%*</td>
<td></td>
</tr>
<tr>
<td>Price (US$/kg)</td>
<td>0.62</td>
<td>0.47</td>
<td>+32%</td>
<td></td>
</tr>
<tr>
<td>Value (US$)</td>
<td>750,000</td>
<td>753,000</td>
<td>-0.4%</td>
<td>-3,000</td>
</tr>
<tr>
<td>Pest control cost (US$):</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pesticide spray</td>
<td>0**</td>
<td>43,000</td>
<td>-94.5%</td>
<td>+40,650</td>
</tr>
<tr>
<td>Male annihilation/ME</td>
<td>2,000</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food bait/GF-120</td>
<td>300</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sanitation</td>
<td>50</td>
<td>0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Production reduced by 25% due to typhoon.
** First time ever, no pesticide application and also no residual hazard.

and season when OFF increase rate reach the high level. The obtained information is then published in a newsletter which is issued every 10 days for pre-warning of fruit fly (Fig. 7). The newsletters are immediately sent to different local farmer associations for reference in taking action to control OFF. In the near future, all those information will be available on the website of the Taiwan Agricultural Research Institute (ARI).

The density of OFF in the past 12 years was under the control of ME bait distributed by the government. Although AW control districts have only been established for 3-4 years, the know-how of new technology developed in this program has been refined through the cooperation of Hawaiian researchers. At the end of four years' program, the success results of the effort were demonstrated clearly in both large district such as Taitung as well as small districts in Chia-yi county. Complete AW control research work will be documented in a standard operation manual by ARI with the opinion and comments from the Hawaiian research group. The manual will serve as a framework and guideline for future OFF control work in different situations and may also serve as the preparation step for
Fig. 6. Good quality bitter gourd was harvested in Pei-Tou area combining male annihilation, GF-120 spray on trap crops and thorough field sanitation

Fig. 7. Newsletter issued every 10 days showing fruit fly density in different areas and the density differences in established AW control districts
fruit exportation through quarantine. The farmer’s groups were invited to meetings to discuss their success and failure, particularly in the conclusion meeting of a COA/USDA collaboration program held in October 12-13, 2005 in Taiwan (Cheng et al. 2005; Su et al. 2005). The Taiwan experience in this program has gained the recognition of the Hawaiian fruit fly working group and the coordinator of the program was invited to attend the 5th APCE meeting held in Cheju, Korea as the co-chair in the fruit fly session, and to exchange the experiences obtained in this cooperative research project conducted in 2000-2004 with participants from other countries.

REFERENCES


