Suppression of Mediterranean Fruit Fly Populations over Mountainous Areas Through Aerial Phloxine B – Protein Bait Sprays: Regional Medfly Programme in Guatemala

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INTRODUCTION

The Mediterranean fruit fly, *Ceratitis capitata* (Wiedemann), was discovered in southern Mexico sometime in 1977 near Tapachula, Mexico. Farmers in Texas and other states of the United States became concerned that the Mediterranean fruit fly would spread northward through Mexico and into the US. In response to this threat to US agriculture, funds were appropriated by Congress to be used by the US Department of Agriculture (USDA) – Animal and Plant Health Inspection Service (APHIS) to eradicate the Mediterranean fruit flies from Mexico and establish a barrier zone in Guatemala to keep the Mediterranean fruit flies from spreading northward into Mexico. In Mexico and Guatemala, the organisation called "Mosca del Mediterráneo" (MOSCAMED) was created to support the programme. Aerially applied malathion bait sprays were used in the suppression programme beginning in Mexico in 1982 and beginning in Guatemala in 1985. Mexico has been free of the Mediterranean fruit fly since 1982, except for outbreaks in the southernmost state of Chiapas, adjacent to Guatemala. The spraying of malathion was banned by the government of Guatemala in early 1996 because of concern regarding possible adverse effects on honey bees. By this time, research had been started to evaluate the use of xanthene dyes as a potential alternative to malathion in protein bait sprays for the suppression of the Mediterranean fruit fly (Liquido et al. 1995). Light-activated toxicity of xanthene dyes has been documented for more than two dozen insect species overall (Heitz 1997). Field trials of xanthene dyes, as a safer alternative to malathion in bait sprays targeting the Mediterranean fruit fly, were begun in Hawaii in 1994 and in Guatemala in 1996 and proved to be promising. By the end of 1996, xanthene dyes were registered as a substitute for malathion to suppress/eradicate Mediterranean fruit flies in the barrier zone. In January, 1997, MOSCAMED-Guatemala began a spray programme with xanthene dyes as the toxicant in a protein bait spray. A second spray cycle was begun in December 1997, targeted to start before the annual Mediterranean fruit fly population increase. The sprays were continued until early February 1998, after which a weekly release of sterile Mediterranean fruit flies was started and was planned to continue through mid-June, 1998.

Here, we describe the 1997-1998 large area phloxine B – protein bait spray programme in southwestern Guatemala. We present the catch results of traps monitored throughout the weekly spray programme, as well as trap catch results from the initial ten weeks of sterile fly release which followed the spray programme. Additionally, we discuss issues which may affect the success of large area suppression programmes which target Mediterranean fruit fly or other tephritid fruit fly species using xanthene dye – protein bait sprays.

MATERIALS AND METHODS

Site Location

The spray trial was located in mountainous coffee growing areas of southwestern Guatemala (Figure 1). The elevation in the spray area ranged from about 400 m to 1300 m. Aerial sprays of the phloxine B – protein bait solution were applied to give complete coverage to 16,700 hectares and alternate swath coverage to an additional 3,800 hectares. An unsprayed 600 hectare control area was located adjacent to the complete coverage spray area (Figure 1).

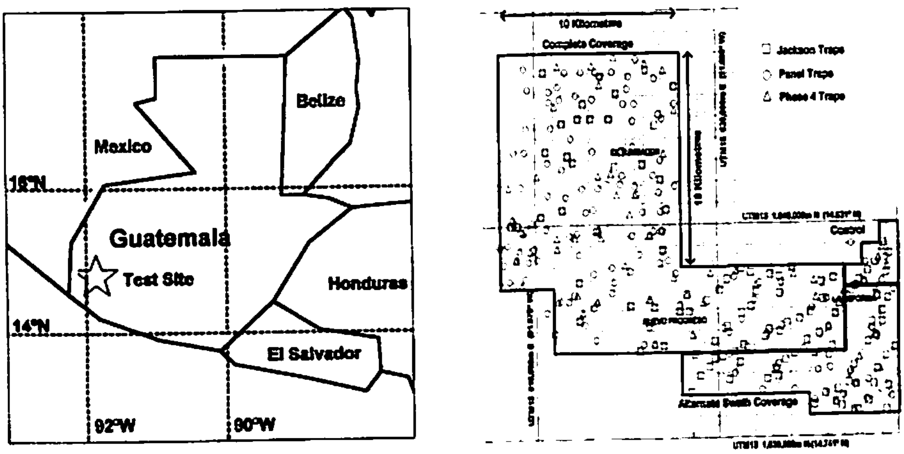

Figure 1. Location of site of aerial phloxine B – protein bait field trial for suppression of Mediterranean fruit fly and dimensions of complete coverage spray area, alternate swath spray area and control area.

Formulation and Application Rate

The protein source used in the phloxine B – protein bait formulation was Mazoferm E802 (Corn Products, Argo, IL). The overall formulation consisted of 40% Mazoferm E802, 20% high fructose corn syrup (which contained about 60% fructose), 0.5% phloxine B, and 39.5% water. The phloxine B – protein bait was applied at a rate of 3.35 litres/ha in the complete coverage spray area and 1.68 litres/ha in the alternate swath spray area. For the complete coverage spray area, this provided about 1570 g Mazoferm E802, 1550 g water, 785 g high fructose corn syrup and 19.6 g of phloxine B per hectare.

Assessing Effectiveness and Persistence of Bait Spray

Each week from the 4th to the 8th week of spraying in the complete coverage spray area, coffee leaves were retrieved shortly after the day's spray was completed. Leaves containing at least fifty 2 mm diameter spray droplets were placed in a plexiglass cubicle (30 x 30 x 30 cm) holding 25 male and 25 female (3-4 day old)

Mediterranean fruit flies. All cubicles had a supplemental water source and half of them had a supplemental food source. Comparable cages were set up using the same number of leaves taken from unsprayed coffee plants. Cages were set outside below a 50% shade cloth to mimic shade provided by coffee foliage. Fly mortality was recorded in these cages periodically over a 24-hour period. Each week, this test was replicated with leaves taken 48 hours and 96 hours after a spray.

Application of Bait Spray

Phloxine B – protein bait solution was sprayed weekly by fixed-wing aircraft. Each plane had six wing-mounted spray nozzles set to provide coverage over a 50 m wide spray swath. Accuracy of application was facilitated through the use of a Global Positioning System (GPS) satellite navigation guidance and recording system.

Complete Coverage Area

In the complete coverage spray area (16,700 hectares), eight weekly sprays were completed from 15 December 1997 to 6 February 1998.

Alternate Swath Area

In the alternate swath spray area (3,800 hectares), six weekly sprays were completed from 5 January to 13 February 1998.

When "hot spots" were detected through weekly trap recoveries in the spray areas, additional localised spraying was performed using helicopters.

Release of Sterile Flies

In the complete coverage spray area, 1,500 sterile male Mediterranean fruit flies of the temperature sensitive lethal (TSL) strain were released weekly per hectare prior to the first spray and subsequent to the last spray. In the alternate swath spray area, 3,000 normal strain sterile flies (male and female) were released weekly per hectare before, during, and after the spray programme. Both releases were scheduled to continue until 15 June 1998.

Monitoring Mediterranean Fruit Fly Population

Three types of traps were placed throughout the spray and control areas: Jackson traps, yellow panel traps and phase 4 traps. These trap types are illustrated and described in Figure 2. Figure 1 shows the location of each trap type throughout the complete coverage spray area, the alternate swath spray area and the control area from a typical trap week. These traps were serviced on a weekly basis starting several weeks before the initial spray. Trap monitoring was scheduled to continue beyond the completion of sterile fly release.

Monitoring Larval Infestation of Coffee Cherries

Coffee cherries were harvested regularly from the complete coverage spray area, the alternate swath spray area and the control area before, during, and after the weekly sprays to assess infestation levels by Mediterranean fruit flies.

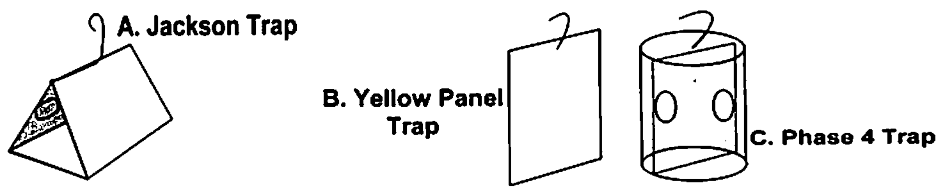

Figure 2. Trap types used to monitor Mediterranean fruit fly population density: A) *Jackson Traps* baited with trimedlure (a male attractant), B) *Yellow Panel Traps* baited with trimedlure, and C) *Phase 4 Traps* baited with ammonium acetate, 1,4-diaminobutane (putrescine) and trimethylamine, a synthetic food bait attractant which attracts both males and females.

RESULTS

Effectivenesss of Bait Spray

Percentage mortalities of Mediterranean fruit flies, by treatment, for the field cage tests, averaged over five weeks of tests, are presented in Figure 3. Mortality after 24 hours in cages receiving freshly sprayed leaves and no supplemental food source averaged 86.5%, with weekly averages ranging from 66.5% to 98%. In cages where a supplemental food source was added, average mortality after 24 hours was only reduced to 83%. In the control cages, average 24 hour mortality was 7.2% and 20.1% with and without added food source, respectively. This suggests that the bait spray should have been effective in the field even considering the presence of alternative food sources.

Persistence of Bait Spray

Average 24 hour mortality of Mediterranean fruit flies in cages without a supplemental food source dropped to 62.6% and 61.2% with leaves collected 48 hours and 96 hours, respectively, after an aerial spray (Figure 3b,c). This showed that the baits maintained significant effectiveness at least four days after a spray application, in the absence of heavy rains (as was the case throughout most of this spray programme).

Population Monitoring: Complete Coverage Spray Area

Spray Period – Adults

By week 2 in 1998, the wild Mediterranean fruit fly population had begun to increase considerably in traps in the control area (see Figure 4a). This was especially apparent in yellow panel trap catches which increased, on an average, from 1.75 to 150.5 flies per trap from week 1 to week 6. However, in the complete coverage spray area, average yellow panel trap catch decreased from 0.683 to 0.052 flies per trap in this same time interval (Figure 4b). By week 6, the week after the last spray, only three flies were trapped on yellow panel traps throughout the complete coverage spray area. The average catch of sterile Mediterranean fruit flies on yellow panel traps in the complete coverage spray area dropped by the third week of spraying and remained less than 5.0 during weeks 1-5, the remaining weeks of spraying, as sterile releases were stopped over the complete coverage spray area during the weeks of spraying (Figure 5b).

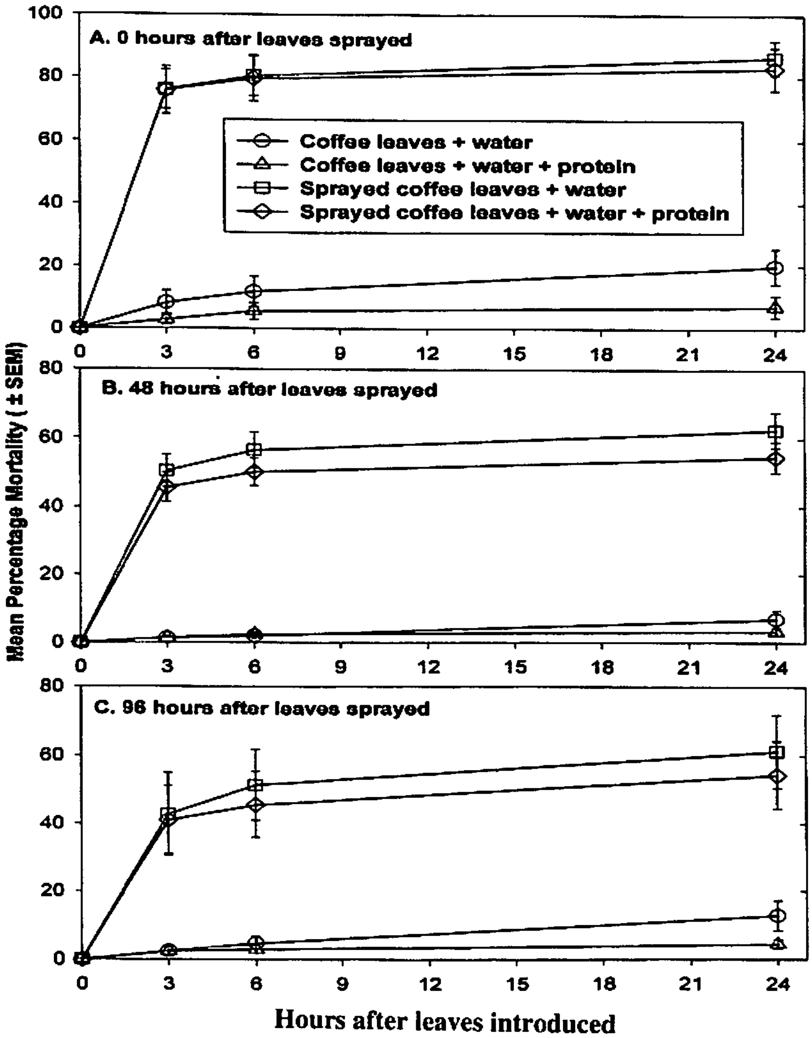

Figure 3. Mean percentage mortality (± SEM) of Mediterranean fruit flies in field cages up to 24 hours after introduction of leaves removed both from coffee plants sprayed by a phloxine B – protein bait spray and from unsprayed coffee plants. Leaves were presented in cages both with and without a supplemental protein source. Leaves from sprayed plants were taken: A) immediately after the aerial spray, B) 48 hours after the aerial spray, or C) 96 hours after the aerial spray.

Post-Spray, Sterile Release Period – Adults

The wild fly catch increased during the post-spray period throughout the complete coverage spray area, although it was still quite low relative to the fly catch in the control area (Figure 4a, b). The average wild fly catch on yellow panel traps in the complete coverage spray area reached a maximum of 5.66 flies in week 11, decreasing

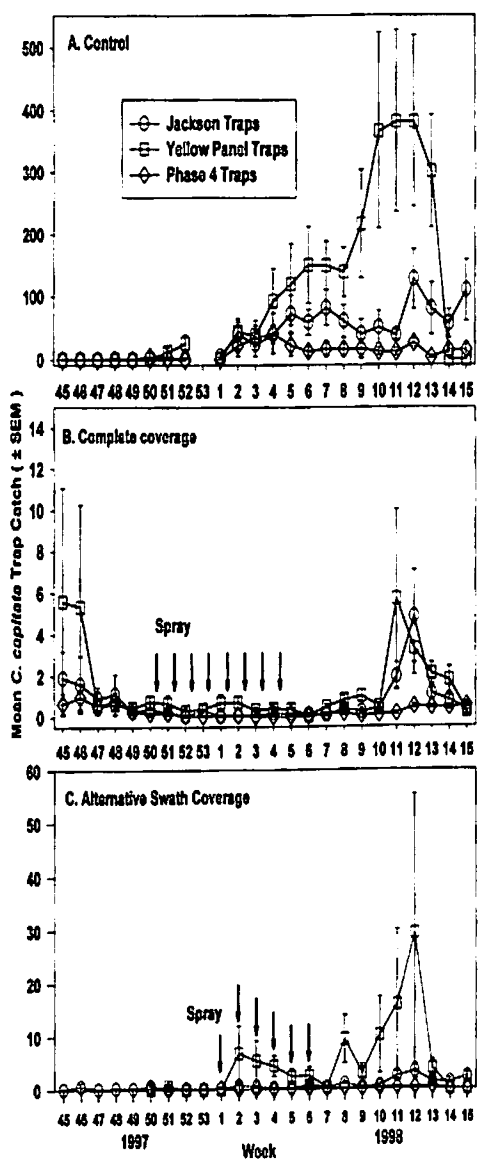

Figure 4. Mean weekly catch (± SEM) of wild Mediterranean fruit flies in Jackson traps, yellow panel traps, and phase 4 traps in: A) the (unsprayed) control area, B) the complete coverage spray area, and C) the alternate swath spray area.

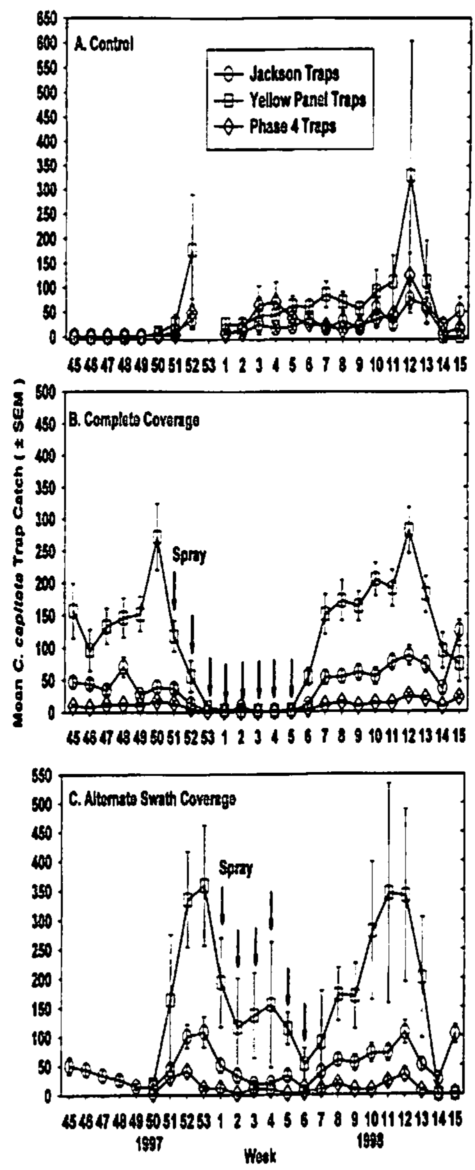

Figure 5. Mean weekly catch (± SEM) of sterile Mediterranean fruit flies in Jackson traps, yellow panel traps, and phase 4 traps in: A) the (unsprayed) control area, B) the complete coverage spray area, and C) the alternate swath spray area.

to 0.24 flies by Week 15 (Figure 4b). In week 11, the average fly catch on yellow panel traps in the control area was 381 and declined thereafter, apparently reflecting the time of natural population decline (Figure 4a). The average catch of sterile Mediterranean fruit flies on yellow panel traps in the complete coverage spray area returned to over 100 flies by week 7, the second week following the cessation of spraying (Figure 5b).

Larval Infestation

Larval infestation of coffee cherries collected from the complete coverage spray area averaged less than 1.0 larva per kg of coffee cherries from the beginning of the weekly sprays through week 6, the 1st week after the sprays ended. By week 7, however, it had begun to increase considerably (Figure 6b). By comparison, larval infestation from the beginning of the weekly sprays through week 6 was consistently greater than 22 larvae per kg of coffee cherries collected from the control area, reached 178 larvae per kg in week 6, and increased further in subsequent weeks (Figure 6a).

Population Monitoring: Alternate Swath Spray Area

Spray Period – Adults

The Mediterranean fruit fly population began to increase in the alternate swath spray area at about the same time as in the control area, but the magnitude of increase was considerably less. During the course of the sprays, the average yellow panel trap catch decreased from 6.75 in week 2 to 0.25 in week 7, the week after the last spray (Figure 4c). In the control area, the average yellow panel trap catch increased from 44.0 to 149.75 during the same period (Figure 4a).

Post-Spray, Sterile Release Period – Adults

The wild fly catch increased throughout the post-spray period in the alternate swath spray area (Figure 4c), although it was still quite low relative to the fly catch in the control area (Figure 4a). Sterile fly release had not been stopped during spray weeks in this area, so sterile fly trap catches continued to be about the same (generally greater than 100 flies per yellow panel trap), following the completion of the spray cycle (Figure 5c).

Larval Infestation

The number of larvae recovered per kg of coffee cherry collected from the alternate swath spray area during the weeks of spraying (Figure 6c), was reduced compared to the level of infestation found in the control area (Figure 6a), but the reduction was much greater in coffee cherries collected from the complete coverage spray area (Figure 6b).

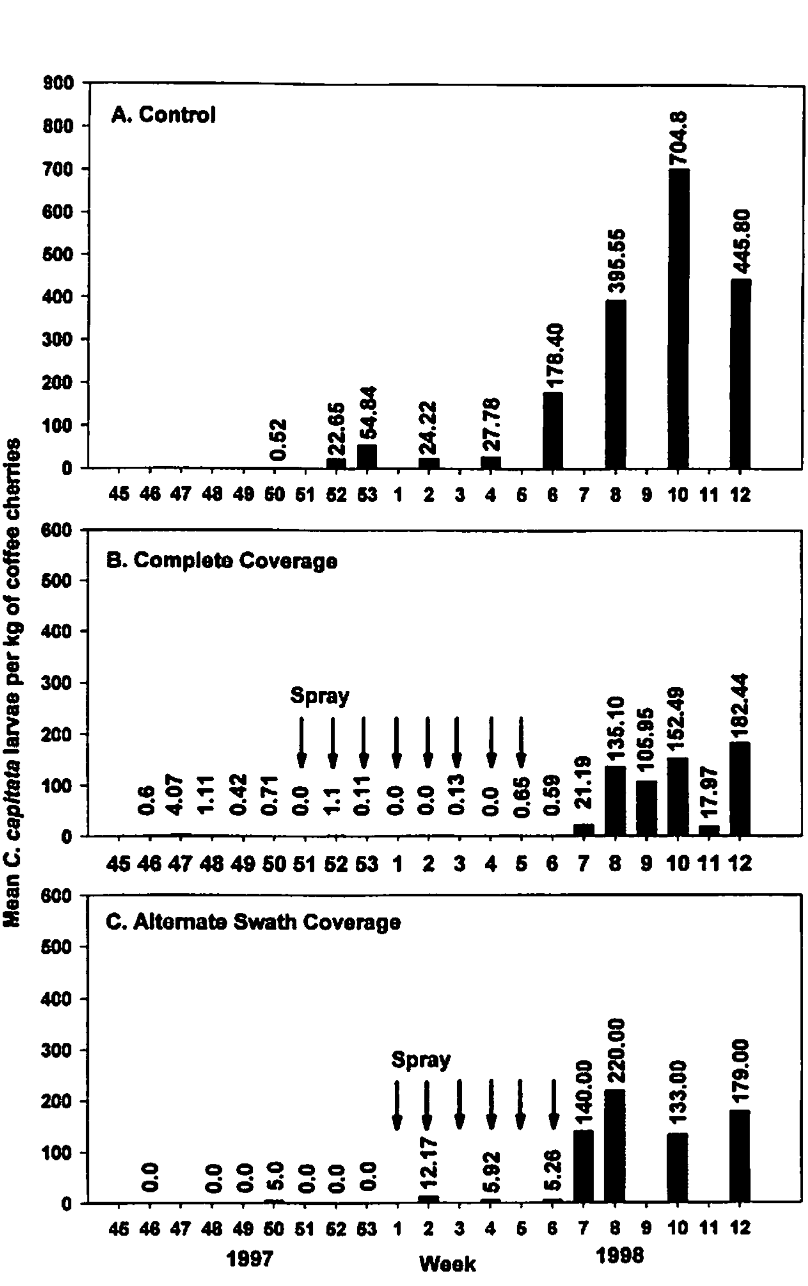

Figure 6. Mean number of Mediterranean fruit fly larvae per kg of coffee cherries harvested weekly from: A) the control area, B) the complete coverage spray area, and C) the alternate swath spray area.

DISCUSSION AND CONCLUSION

Effectiveness of Suppression

The results presented here show that phloxine B – protein bait sprays provide good suppression of Mediterranean fruit flies in mountainous coffee growing areas, especially during dry weather conditions such as prevailed throughout the present study. Applying the spray in alternate swaths provided some suppression of Mediterranean fruit fly populations, but much less than that provided by a complete coverage spray. The complete coverage spray programme, combined with the release of sterile flies, was, however, not able to achieve eradication of Mediterranean fruit flies in the area of coverage.

Potential Factors Affecting Effectiveness of Suppression

Weather

Weather conditions were very favourable for this study as there was little problem with rain following the sprays. Rain soon after a spray can severely impact the effectiveness of the spray programme. As seen in this study, under dry conditions, the dye-bait solution can remain effective for several days after the spray.

Time of Spray (Time of Day)

In the spray area, updrafts which occur later in the day can adversely affect the uniform distribution of the dye-bait solution. Consequently, MOSCAMED aimed to spray only during morning hours and began to reverse the order of spraying in successive weeks, so that the same area was not always the last to be sprayed.

Time of Spray (Seasonality)

The spray programme was started prior to the anticipated annual Mediterranean fruit fly population increase. This timing is important to maximise spray programme effectiveness.

Duration of Spray

Good suppression was shown in the course of the spray programme, but population increase was observed after the cessation of the spray despite resuming the release of sterile flies. It would have been desirable to extend the spray programme until after the natural seasonal population reduction was observed in the control area. We recognise that the additional programme cost could be problematical.

Delivery Problems

- *Areas Where Shade Trees are Well Developed*
  Shade trees are routinely planted throughout the coffee growing areas. In places where these trees are well developed, the dye-bait solution may not readily reach the coffee plants and thus, may not be located by the Mediterranean fruit flies. It was not clear from this spray trial whether this

was actually a problem in certain sections of the spray area. This potential problem needs further attention.

- *Localised Wind Patterns*
  The complex topography involved here raises questions of whether localised wind patterns kept the dye-bait solution from reaching certain areas. Micro-climatic wind patterns could tend to keep the dye-bait solution from reaching certain areas within the intended coverage area.

Low Light Problems

It is possible that where there is sufficiently reduced light conditions on steep north-facing slopes, mortality rates could be significantly reduced, especially considering that these slopes will also have less dye-bait solution applied per unit area relative to flat areas. Further trappings in these areas are needed to investigate the significance of this possible limitation.

Recommendations for Future Spray Programmes

The results here suggest that it is necessary to prolong the duration of weekly sprays in areas where Mediterranean fruit fly populations are established until after fly populations in the control area reach their natural seasonal decline. Phloxine B bait sprays appear to have some limitations on their effectiveness. Many of these need further study. We recommend that conditions which could adversely impact the effectiveness of a spray programme be identified as soon as possible and that measures be included in the spray programme to assess the effect of these potential problems. For example, in this programme, additional trapping might have been used in areas where coverage was suspect (e.g., due to such factors as slope, wind pattern, and overstory) to determine if flies were escaping treatment in these areas.

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