# Trip Report

Mali/Senegal.

1 March – 3 April 2010

## IPM CRSP Associate Awards:

## Development and Promotion of Integrated Management of Mango Pests in Senegal

**USAID/Senegal Associate Cooperative Agreement No. 685-A-00-08-00065-00**

## Africa Food Security Initiative – Quality Food Production, Availability, and Marketing

**USAID/EGAT Associate Cooperative Agreement No. EDH-A-00-08-00015-00**

## Mali: Building Local Capacity in IPM Solutions

**USAID/Mali Associate Cooperative Agreement No. 688-A-00-10-00015-00**

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**Countries Visited/Dates of Travel:** Senegal 3-7 March 14-25 March; Mali 7-14 March

**Traveler Name and Affiliations:** Larry Vaughan, IPM CRSP Associate Program Director. Also conducting international travel described in this report are:

To Senegal:
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Issa Sidibe, OHVN Mali;
Roger Vargas, USDA/FAS, Hilo Hawaii

To Senegal and Mali: Ron Stinner, North Carolina State University

To Mali:
Ozzie Abaye, Virginia Tech
Maria Elisa Christie, Virginia Tech
Pat Hipkins, Virginia Tech
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**Purpose of Trip:**
Mali: Workplan meeting for new Mali IPM associate award funded by USAID/Mali
Senegal: Review and planning for ISRA's activities in the USAID/EGAT-funded African Food Security Initiative associate award. Field trial planning and other project coordination tasks for the USAID/Senegal-funded Mango IPM project.

**Sites Visited:**
***Senegal AFSI:*** St. Louis, Ross Bethio, Dagana, Gnith (Lac de Gueirs)

***Mali IPM:*** Bamako, Farabana (Bamako peri-urban vegetable production along the Niger River)

***Senegal Fruit Fly:***
1. Basse Casamance (Ziguinchor, Oussouye, Boucott, Loudia Oulof, Nyassia/Darsalam, Djibelor, Diouloulou, Kabar (Diana), Kaffountine);
2. Thies/Niayes (Wayambam, Bayah, Diégueun, Niass (Ndiass), Garage Benteniér

**Description of Activities/Observations:**
The trip was divided into three parts. The first week of was devoted to the food security project, for which ISRA is the Senegalese partner.

The second week of the trip was highlighted by the workplan meeting for the new Mali IPM associate award. Representatives of all host country partner institutions except one

were present. During the two-day meeting the approved project proposal was outlined and the proposed activities were reviewed, augmented – and when necessary – modified.

During the third and fourth weeks of the trip, I was back in Senegal to focus on setting up the area-wide fruit fly management trials for the mango IPM associate award. The work included a tour of the Niayes area northwest of Thies to visit areas that may become treatment blocks in the large-scale tests. A similar visit was made in Casamance south of the Gambia, where the environment is substantially different from Niayes and where mango production faces different challenges with respect to fruit fly management.

Most of the fourth week was personal leave, although I set some methyl eugenol and terpinyl acetate parapheromone traps in St. Louis and Palmarin (in the Sine Saloum) to survey for the presence of *Bactrocera invadens* and *Certatitis cosyra*. *C. cosyra* was found at both sites and *B. invadens* was not.

***Week 1 – Senegal. IPM CRSP African Food Security Initiative***

I spent most of the week in the region of St Louis working with ISRA colleagues on the 2010 activities for the AFSI associate award. The two principal activities are: promotion of the no-host period for managing tomato virus in the Senegal River Valley; and evaluating the reduced weed problems, and improved rice yield when rice fields are leveled. Two Malian resource people familiar with implementation of the no-host period in Mali joined me in Senegal – Moussa Noussourou, the person who originally demonstrated the efficacy of the no-host period in Mali – and Issa Sidibe, who has lead implementation of the no-host period by his institution (OHVN) in the peri-urban production zone of Kati.

On Tuesday March 2, the three of us traveled to St. Louis with Samba Diaw, chief of the horticultural laboratory at IDRA/CDG. On Wednesday March 3 we traveled with Souleymane Diallo and Omar Faye (both weed scientists) to visit tomato production zones. the team at ISRA St. Louis and planned the field excursions. We visited the SAED Dagana station at Ross Bethio east of St. Louis and west of Richard Toll, where we met the delegué of the national tomato committee, Monsieur Diallo, and the SAED Chef de Secteur, Piram Diouf. There are about 1400ha of processing tomatoes planted each year out of approximately 6000ha in the Senegal Valley. Tomatoes are usually grown in the dry season after rice has been harvested. Horticultural production in the valley is worth about 9 billion CFA with tomatoes accounting for 6 billion CFA. Observation and local opinion support onions as being the second most important vegetable cash crop. About 800ha of onion were planted in the current season. Ten tons/ha is the profitability threshold for onions there. Cash from tomato production is used to repay input credit for rice production. Much of the rice that is produced is consumed locally. The production cost of rice is about 100CFA/kg compared to 220 for purchased rice. Around Ross Bethio there wsa not as much tomato planted as usual because many growers were unable to sell all of their rice, and could not get credit for tomato inputs. Whereas rice is the mainstay of smallholders working the irrigated parcels of SAED, an increase in vegetable production at the expense of rice may be occurring because of its profitability. There is a

law that prevents onions from being imported between 1 March and the end of August in order to favor local production. Large quantities of imported onions were noted stacked inside and outside warehouses in Dakar. Trucks full of onions were making deliveries to villages as far up the valley at the Podor.

We were presented with the 2008/2009 technical recommendations (*fiche technique*) produced by the national tomato committee (CNCFTI). These fertilizer and pesticide recommendations are required to be followed by all producers seeking bank credit for inputs. The recommendations include calendar spraying of insecticides, fungicides use in the nursery and field, and contained no guidance on safe use. Tomato varieties that were recommended were Rio Fuego, Rio Grande, Gempride, Progress, and Yakil. We observed Gempide, Yakil, and a variety known locally as "Goodyear". Yakil is considered tolerant to tomato yellow leaf curl virus (TYLCV), yields well. We observed symptoms on producing plants. In the valley, TYCLV is known as tomato leprosy (*lepre d tomate* or *ngana tomate bi* in Wolof).

The vast majority of tomato production is coordinated by the national tomato committee and destined for the two canneries in the valley where they are sold at a fixed price. However, there is also some horticultural production outside the committee. In the normal production calendar, the nursery is prepared in August and September, with the majority planting in September, but some planting as late as November. The SOCAS cannery open in late January or early February. Harvest is heavy in March and ends by mid May at which time the canneries close. The Dagana cannery opens the second week of March. After harvest, the plant residue is consumed by livestock, which Moussa Noussourou noted was different from the situation he has found at irrigated zones of tomato production in Mali.

There is some rainy season tomato production for the fresh market, which takes advantage of high prices. Whereas a crate of fresh market tomatoes will fetch 1,700 to 2,500CFA, the rainy season tomatoes can earn 12,000 or 13,000CFA. In addition to onion production, hot pepper is also profitable. It is planted in March and grown through the rainy season to again take advantage of high prices. Pepper production was reported to be an almost exclusively male undertaking, with only one women's group known by the SAED personnel to grow it on about 18ha.

We stopped at a tomato field 12km east of Dagana and responded to a growers request that we look at some Gempride tomato plants. Moussa Noussourou did the water bottle test to check for bacterial wilt, but the test was negative, suggesting an infection by the fungus *Fusarium* sp. In discussing the need for IPDN to expand to field agents who interact with farmers, it was explained that ISRA/St. Louis does not have a microscope. In this area we saw maize being planted as a windbreak for tomato fields.

On Thursday 4 March, we visited fields around the Lac de Gueirs reservoir to find a new area for testing the no-host period in 2010. The lake runs north-south for about 18km; we decided to create two management area – one on the east side of the lake and one on the west side of the lake. We visited the west side of the lake at a *Communauté Rurale* of

Gnith and the village of Malle. There we found symptoms of *Alternaria* sp, but was told that it occurs late in the season and does not case a problem. We visited a field of cherry tomatoes intercropped with manioc and found no whiteflies. One of the cherry tomato fields was 12ha according to the man who leased the land. Most of the tomato production in this area was fresh tomato rather than process tomato under the coordination of the national tomato committee. Demba Farba Ndiaye arrived from Dakar in the evening.

On Friday March 5 we had a team meeting to review what had been learned and plan the AFSI activities for the year according to a revised workplan. Mamadou Ndiaye filled in as interim station chief in the absence of Director Cisse. Present from ISRA were Aminata Ba Sow, sociologist; Souleymane Diallo, weed scientist; Demba Faba Mbaye, CDH director, Omar Ndaw Faye, weed scientist, and Samba Diaw, horticultural. Moussa Noussourou, Issa Sidibe, and I also participated. We first discussed the problem in 2009 of mobilizing funds across three stations with a $6000 advance. We agreed on the importance of regular invoicing to facilitate the continued flow of money; something that was not accomplished the prior year, resulting in the inability to fund the work. Demba explained a new accountant was in place and would be working with him closely to prepare regular invoices. We reviewed all activities in the workplan and discussed how they will be carried out during the season.

Upon returning to Dakar I met Keith Moore of OIRED, and Ron Stinner of North Carolina State University, both of whom continued on to Mali for the workplan development meeting for the new Mali IPM associate award.

***Week 2 – Mali – Associate award for IPM capacity building***

With the valuable assistance of our longtime partner Issa Sibibe of OHVN, I visited the Malian plant protection service (*Office de Protection Végétaux*, OPV) and the national agriculture agency (*Direction Nationale D'Agriculture*, DNA). These institutions, along with *Office du Niger* (ON) are new to the IPM CRSP, so an orientation before the workplan meeting was in order. We discussed the anticipated roles of each institution in the project. On the way back from OPV, I stopped by some pesticide dealers near the Ministry of Agriculture to discuss their experience with pesticide safety training. Unlike previous inquiries, I found one dealer who had recently been trained by the company Cigone. The dealers expressed interest in learning more about the products they sell na and how to handle them safely. Scheduling constraints prevented Issa and me from making more than telephone contact with the Director General of ON whose office is in Segou. I also met with Kadidiatou Gamby, Chief of the fruits and vegetables laboratory at IER/Sotuba. We discussed implementation issues for all three IPM CRSP programs in which IER is involved. Maria Elisa Christie and I met Jacques Hommes, Director of Mali Protection de Cultures, a phytosanitary products dealer near the hotel in Bamako. I went in to learn about its pesticides, but discovered that MPC also sells seeds. Mr. Hommes was interested in my explanation of the need for seed importers to carry the improved tomato varieties that have been demonstrated to work well with the no-host period. I promised to arrange a meeting between him and Bob Gilbertson of UC Davis, who has connections with seed suppliers.

Ron Stinner came to Mali to work with DNA on a proposed phytosanitary database. He worked with Timbo Bakary of DNA to outline the database needs and IT capabilities of DNA with the objective of helping it better address its phytosanitary reporting responsibilities to the International Plant Protection Convention.

On Tuesday 9 March and Wednesday 10 March, we held a workplan development meeting. The morning of the first day comprise a general presentation of the proposed activities, introduction of partner institutions, and a special presentation by OIRED's Program Director for Women in International Development on the gender aspects that need to be treated in the project. In the afternoon the participants broke into four workgroups that corresponded with: 1) IPM package research on tomato and potato; 2) phytosanitary database development; 3) capacity building for the pesticide residue laboratory at the Central Veterinary Laboratory (LCV); 4) extension of the host-free period for tomato virus management and pesticide safety training. On the second day of the workshop, the groups continued working in the morning. The afternoon was a plenary session in which each group presented its portion of the workplan, which was then discussed by the whole group.

On Thursday morning Ron Stinner and I had a meting at DNA to share with the DG the workplan that he and Timbo had developed. Don Mullins, Madame Gamby, and Issoufou Kollo met to discuss Issoufou's role in promoting the IPM CRSP disease diagnostics network and in building capacity at IER/Sotuba to manage the new biotech laboratory. In the afternoon, Ozzie Obaye and I had a meeting Djiguiba Kouyate at the economic growth project IICEM. We discussed our collaboration in promoting women's groups' production of certified rice seed in the Sikasso region. In particular we discussed the need for improved fertility management, for which Ozzie will contribute technical assistance, and the possible role of IICEM in ensuring availability of fertilizer to the women. On Friday 12 March Madame Gamby took Pat Hipkins and myself to Farabana, a peri-urban vegetable production zone outside Bamako next to the Niger River. There were large plots of eggplant, African eggplant, and onions. One particular plot of African eggplant was heavily infested with aphids, whereas the other plots of African eggplant were not. The grower explained that the aphid-infested plot was the one plot where he did not water the foliage. Ron Stinner and I departed for Senegal on Sunday.

***Weeks 3& 4 – Senegal – Associate award for mango IPM (fruit fly project)***

1. Database revision – University of Thies/ENSA
2. Area-wide management assessment with USDA
   - Field trip to Thies/Niayes
   - Field trip to Basse Casamance

Ron and I arrived in Senegal Sunday evening March 14. We drove directly to Thies. On Monday morning we went to ENSA at the University of Thies to meet with Professor Saliou Ndiaye and Marie Dieng, the IT specialist hired by the fruit fly project. Ron and Marie worked for two and a half days on the database for long-term population monitoring of fruit flies. The database needed revision to adjust for changes made in the long-term monitoring protocol. I returned to Dakar to meet with the head of the zoology

department at the University of Dakar, Cheikh Tidiane Ba. We discussed the process of setting up a subaward with Virginia Tech to support two graduate students that were being transferred to UCAD to continue their fruit fly research. Roger Vargas arrived from Hawaii Wednesday morning. Roger and I went to DPV to meet Kemo Badji, head of the entomology lab and national coordinator of the fruit fly project. We met Ron coming back from Thies and returned together to Dakar, where he left early the following morning.

Roger came to Senegal to provide technical assistance in evaluating the potential for doing area-wide fruit fly management. Roger's trip was made possible through a regional agreement between USAID and USDA. In the north, Roger toured mango producing areas of Niayes (Wayambam, Bayah, and Diégueun) with a DPV team (Djibril Djiba and Kalilou Bodiang) on 18 March. On 19 March was a meeting with ANCAR/Thies. On 20 March he visited the production area around N'Diass (Garage Benteniér) with ANCAR/Thies agents Bineta Mbengue Dieye and Issa Diop. We then visited the retail sales area at Pout, which will be the focus of efforts to understand fruit fly population dynamics between nearby orchards and retail areas. On 23 March a team comprising Roger Vargas, Kemo Badji (DPV), Elhadji Dieng (DPV), Aminata Badiane (USAID/Senegal) and Larry Vaughan (Virginia Tech) went to Casamance. The team met the ANCAR/Ziguinchor Regional Director, Mamadou Dione. The field visit in Casamance was guided by the ANCAR/Ziguinchor point person for mango, Raphael Biagui, and Demba Keita of the NGO APRAN. The team visited Loudia Ouolof, Darsalam, Djibelor, Diouloulou, Diana (Kabar), and Kafountine. Roger wrote a report with recommendations for tackling an area-wide management scheme (**Annex 1**). The report was translated into French by Elhadji Dieng.

As in 2009, the 2010 field trials comprise two treatments: 1) male annihilation technique (MAT) using a locally produced product called Malatrap (Senchim); 2) MAT plus protein baiting for females with Success Appat (Dow Agrosciences). The big difference between 2009 and 2010 is the area-wide approach. Treatments will be implemented in multi-orchard blocks through a cooperative of adjacent growers. Both treatments will require good field sanitation as a pre-requisite for receiving the materials. Malatrap is 75% methyl eugenol parapheromone and 75% malathion presented in a trap made from plastic water bottles. Success Appat is a protein hydrolysate combined with a small quantity of the organic insecticide spinosad.

Roger's departed early morning Thursday 24 March to return to Hawaii. On Thursday I had a debriefing at USAID with Aminata Badiane, the project AOTR and a brief visit with Peter Trenchard, Team Leader for Economic Growth. I then visited Mamadou Dabo at the SAGIC economic growth project to present my suggested revisions for the new mango fruit fly booklet. He and I also talked with Dick Cook, head of SAGIC's agriculture activities about the possibility of getting ISRA a laser-leveler for carrying out the field leveling needed for AFSI research.

Friday 25 March – 2 April: personal leave. While in St. Louis and in the Palmarin area of the Sine Saloum Delta , I placed methyl eugenol and terpinyl acetate traps to check for

the presence of *Bactrocera invadens* and the native fruit fly *Ceratitis cosyra*, respectively. In both places I caught *C. cosyr*a, which is expected given its prevalence in the dry season. The lack of *B. invadens* indicated there were no or very small refuge populations in these places.

**Organization Abbreviations:**

ANCAR. *Agence Nationale de Conseil Agricole et Rural*. Senegal
APRAN. *Association pour la Promotion Rurale de l'Arrondissement de Nyassia*. Ziguinchor, Senegal
CDH. *Centre de Développement pour l'Horticulture* (ISRA). Dakar, Senegal
DNA. Direction Nationale d'Agriculture, Mali
DPV. *Direction de la Protection Végétaux*, Senegal.
CERES *Fondation Centre de recherches en écotoxicologie et sécurité environnementale*. Dakar,
CNCFTI. *Comité National de Concertation sur la Filère Tomate Industrielle*
ENSA. *Ecole Nationale Superieure d'Agriculture*. University of Thies, Senegal
IICEM *Initiatives Integrées pour la Croissance Economique au Mali*
IER. *Institut d'Economie Rurale*, Mali
ISRA. *Institut Sénégalais des Recherches Agricoles*. Dakar, Senegal
LCV *Laboratoire Central Veterinaire*
LTCQE. *Laboratoire de Toxicologie et du Controle de Qualite Environnementale. Bamako*, Mali
OHVN, *Office du Haute Vallée du Niger*. Bamako, Mali
OIRED. Office of International Research, Education, and Development. Virginia Tech
ON. Office du Niger
OPV. *Office de Protection des Végétaux*, Mali
SAED. *Societé Nationale d'Amenagement et d'Exploitation des Terres du Delta du Fleuve Sénégal et des Vallées du Fleuve et da la Faléme*
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**Annex 1. Roger Vargas's Trip Report for Evaluation of Potential for an Area-wide Approach to Fruit Fly Management in Mangoes.**


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PROJECT TITLE: Integrated Pest Management Collaborative Research Support Program (IPM, CRSP): Management of Invasive Fruit Fly Species in Mangos in Senegal

DURATION: March 15-25, 2010.

ASSIGNMENT TITLE: Management of Invasive Fruit Fly Species in Mangos in Senegal.

DUTY STATION: Dakar, Senegal


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BACKGROUND INFORMATION: Fruit flies (Diptera: Tephritidae) have a serious detrimental economic impact on tropical and sub-tropical agriculture worldwide and pose a continuing threat of establishment into new areas. West Africa is a region of growing economic importance for fruit production and export. Mango, *Mangifera indica* L. is an important crop in local, national, regional and international markets. Mango fruit production provides essential nutrition and a valuable source of income in many West African countries. In West Africa, four fruit fly species, *Bactrocera invadens* Drew, Tsuruta & White, *Ceratitis cosyra* (Walker), *Ceratitis silvestri* Bezzi and *Ceratitis quinaria* (Bezzi) cause significant damage to mango fruit (Vayssieres et al. 2009). *Ceratitis* are native species; *B. invadens* is a recently introduced invasive species. Reports from other West African countries suggest, *Ceratitis* species occur during the dry season and the main species, *Ceratitis cosyra*, reaches a peak at the end of the dry season (Vayssieres et al. 2009). *B. invadens* populations are scarce during the dry season, but increase rapidly from the end of April to reach a peak at the end of June during the rainy

season. During the early rainy season *B. invadens* causes considerable damage to mid and late season mango fruits (Vayssieres et al. 2009). Estimates suggest damage to mangos increases from less than 25% in early April to greater than 75% in July, primarily due to B. invadens attack.

ASSIGNMENT DUTIES: 1) Review field situation and available information on mango production, losses and fruit fly control, and indicate missing information.
2) Review fruit fly monitoring data available and indicate additional base-line information that needs to be collected.
3) Suggest other activities required to be carried out for the eventual establishment of area-wide integrated fruit fly suppression program in mango production areas in Senegal.

TERMS OF REFERENCE: My trip was funded by the USDA/FAS/OCBD/Trade & Scientific Capacity Building Division. My major objective was to advise on development and implementation of area wide IPM procedures for suppression of fruit flies in Area-Wide Pest Management (AWPM) programs for mango. In Senegal, I met with Dr. Larry Vaughan and his counterparts, reviewed operations and toured mango production areas where monitoring, male annihilation and protein treatments were either underway or planned. Dr. Vaughan's research team is very knowledgeable, professional, and dedicated. Without their outstanding assistance, I would not have had such a productive trip. The mango project is very necessary to Senegal and the farmers spoke very strongly about the immediate need for fruit fly control in mango orchards.

RECOMMENDATIONS:

1. Senegal has 5-6 vegetation zones that occur from north to south and extend from the Atlantic Ocean inland. Zones are determined by climate (i.e. rainfall patterns). Fruit fly population dynamics by species associated with these different vegetation zones need to be determined using traps baited with methyl eugenol, terpinyl acetate, trimedlure, and torula yeast during 2010–2011. Population fluctuations should be analyzed with respect to environmental factors such as air temperature, relative humidity, rainfall, cultivated hosts, and wild hosts. This could be accomplished by a north-south trap line spaced at regular 10 km intervals (Vargas et al. 1983a; Vargas et al. 1983b).

2. Fruit flies associated with mango orchards need to be monitored intensively using traps baited with methyl eugenol, terpinyl acetate, trimedlure and torula yeast during 2010–2011. Two major areas of interest are mango production areas at Thiés and Ziguinchor. Population fluctuations in these two areas in the north and south, respectively, should be analyzed with respect to environmental factors such as temperature, relative humidity, rainfall and alternative hosts in relation to different mango cultivars (early and late maturing varieties). Mango fruits should be sampled to assess the damage (i.e. oviposition scars and fruit flies/kg) caused by fruit flies. Presumably, mangos in the north enjoy the advantage of fewer reservoir hosts and an arid climate most of the year, with respect to *B. invaden*s (Vargas et al. 1989; 1990; Vayssieres et al. 2009).

3. To evaluate demonstration sites, more fruit collection data are absolutely necessary, in addition to improved trapping grids (at least 2 male traps per ha and 5-10 female traps per ha). Simple spatial evaluation grids can be generated using ArcInfo GIS software. Google Earth would be invaluable for pinpointing hosts in the different vegetation zones and physical barriers to fruit flies surrounding potential demonstration sites. Study grids are useful to evaluate the impact of wild host reservoir areas surrounding agricultural demonstration sites. Plastic McPhail or Ball traps with torula yeast bait should be used to monitor female fruit fly activity within orchards. This is the true measure of population pressure within the orchard. Male trap data can often be misleading, because traps attract flies from such large distances. Comprehensive summaries of fruit fly captures by location also would be useful to determine overall differences in spatial dynamics of fruit flies in the north and the south mango production regions of Senegal (Vargas et al. 2010c).

4. The natural enemies, *Fopius arisanus* (Sonan) and *Diachasmimorpha longicaudata* (Ashmead), should be considered for introduction into Senegal after approval is obtained from the appropriate government agencies. *F. arisanus* and *D. longicaudata* have been shown to have a significant impact against oriental fruit fly and Mediterranean fruit fly (Vargas et al. 1993; Vargas et al. 2001; and Vargas et al. 2007) in Hawaii. Parasitoids could have a significant national and regional impact on *B. invadens* and *Ceratitis* species in Senegal and nearby countries. The United States Pacific Basin Agricultural Research Center (USPBARC) has done recent parasitoid work in Reunion Island and French Polynesia with peach fruit fly and oriental fruit fly, respectively. Future trainees could bring wasps back to Senegal from Hawaii or Reunion Island where a rearing program was developed from technology transferred from Hawaii. Possibly, *F. arisanus* has already been sent and established in another country on the African continent (e.g. Kenya or Benin) where *B. invadens* work is underway. I would be happy to expedite the effort to establish *F. arisanus* and *D. longicaudata* in suitable areas of the African continent and would be willing to write a small FAS grant proposal for this purpose. Overall, this may be the most cost effective approach to reducing *B. invadens* populations regionally.

5. Integration of sanitation, protein bait sprays and male annihilation (the 1, 2, 3 Approach) is a sound IPM approach developed over the last decade for fruit fly control in Hawaii. A successful demonstration in local agricultural areas for *B. invadens* would have major applications to area-wide fruit fly control not only in Senegal, but also throughout Africa. Significant support should be made available for this effort. Kémo Badji and his technical staff have the expertise to conduct small pilot tests of sanitation, bagging, protein baiting, and male annihilation. However, the group is seriously undermanned for undertaking large AWPM programs and need to prioritize small subprojects. Small demonstration tests should be conducted at several mango farms at Thiés and Ziguinchor before expanding programs to include larger areas (Mau et al 2007; Vargas et al. 2008; Pinero et al. 2009a).

6. During the low part of the fruit fly population cycle, control efforts should emphasize MAT applications. Indications are that *B. invadens* populations are low during the dry

season and in dry habitats. MAT treatments can be very cost effective when populations are low. Subsequently, parasitoid introductions should be done over the next 2 yr. If small-scale tests produce positive results, expanded area-wide tests should be pursued further (Mau et al 2007; Vargas et al. 2008). In the south some criteria for evaluation sites might be: 1) Selection of similar size control vs treatment plots, 2) Plots with the same cultivar, 3) No chemical sprays, 4) Plots < 2 ha each, 5) Easy access by car, 6) Limited amount of surrounding reservoir hosts, 7) Some semblance of isolation, and 8) Sites with current Google Earth map vegetation data (Vargas et al. 2000; 2003; 2005; 2008, 2010).

7. In the Ziguinchor area extension agents should be used to transfer the 1-2-3 approach to farmers immediately and be provided with bags to protect late season mangos from fruit fly attack. The complexity of the environment, large size of the mango trees and abundance of alternative hosts makes the Ziguinchor area much more challenging than the Thiès area.

8. Studies on possible accidental introduction of fruit flies via fruit trucks bringing produce into Pout from the the Casamance, the Gambia, Mali, and Guinea are very important and should be undertaken by Madame Bineta Mbengue Dieye. These studies will help determine if *B. invadens* is being regularly introduced from the south to Pout from commerce or if the source of the breeding populations is primarily the nearby orchards.

9. Bagging trials with mango fruits are also very important and should be started immediately by Monsieur Elhadji Dieng with different products available locally. I will have bags used in Taiwan for mango, wax apple, and guava production sent to Larry Vaughan for evaluation in Senegal. These could be used to protect late season mango fruits on trees subject to *B. invadens* attack. Currently, candidate bags being sold in Taiwan include: (1) Standard brown paper with wax (21.5cm X 35cm, Sinon® #9616): 140 NTD per 100 pieces. (2) Irwin enlarged (15.5cm X 28.3cm X 4.5cm, Sinon® #9615): 80 NTD per 100 pieces. (3) Standard enlarged (15cm X 27.3cm X 5cm): 100 NTD per 100 pieces. The standard brown bag is a flat one, but the two others both have a depth of 4.5-5cm. Actually (2) and (3) are normally used for mango. However, if they are growing a larger size of mango fruit, Irwin may not work, and we need to find a bigger bag.

10. Several demonstration sites for evaluation of GF-120 (Success Appat) should be identified as protein treatment (GF-120) test sites. Supplies of Success Appat are limited and expensive. Furthermore, mango trees are very large. Vayssiere et al. (2009) recommended: 1) Dilution of GF-120 by 5:1 (water: GF-120), 2) Spraying 1 $m^2$ areas of tree at head height weekly, and 3) Treating all mango trees and surrounding hosts. In order to conduct further tests: 1) Bait stations should be tested (see Pinero et al. 2009b), 2) Further dilution of the GF-120 might be considered up to 10:1, and 3) Spraying of the inner canopy of trees considered for protection from rain. For a replicated experimental design and statistical analysis information see recent tests in Hawaii papaya fields by Pinero et al. (2009a). For Jaime Pinero to complete the protein trials in papaya, he used 6

people and three ATV's over several months. For information on bait stations to prolong GF-120 applications see Pinero et al. (2009b). Many potential sites were visited at Thiés, but the final decision for a test site should be left up to Kémo on the basis of available staff and distance to site. My advice is to conduct research evaluations in the north (Thiés) and immediately implement the "1, 2, 3 approach" in the south (Ziguinchor) through extension agents.

11. The impact of male annihilation traps to be deployed also needs to be tested in Thiés and Ziguinchor. Traps need to contain at least 10 ml of a Malatrap solution and be placed at a density of 10-20 per hectare just after flowering ends in the mango orchard. The original loads used to eradicate oriental fruit fly by Loren Steiner in the Mariana Islands during the 1960s was a canec block containing 20 ml of Malatrap. Traps should be re-baited at 12 wk intervals (Vargas et al. 2000; 2003; 2005; 2008, 2010c). Application of Malatrap holds the potential to reduce *B. invadens* buildups that damage late season mango fruits. Late season bagging is another tool to protect mango harvests from late season maturing mango cultivars susceptible to fruit fly attack.

12. Demonstration sites in Thiés and Ziguinchor should be a cooperative effort among entomologists, extension agents, government agencies, farmers, and suppliers of suppression products. Dow AgroSciences has been contacted and has agreed to provide technical assistance in training the farmers on how to use GF-120 (mvilleneuve@dow.com and sdip@orange.sn). They have sent Larry and Kémo GF-120 application and use pattern instructions.

13. Of particular value to the program is the documentation of reduction in damage to fruit grown in "treated vs control" plots. To accomplish this task, a fruit holding room will need to be established, possibly at the old ISRA facility near Ziguinchor. Subsequently, fruit samples should be collected from treated and control areas and evaluated for damage. Data should be summarized in simple tables and graphs for distribution to participants. Information of this type is very important to demonstrate and promote the value of the program to cooperators and stakeholders. More importantly, this information will provide baseline data for the impact of introduced natural enemies (see Vargas et al (2007) for fruit processing procedures).

14. Integration of male annihilation and protein baits with releases of small numbers of parasitoids could be completed within the next few years at selected agricultural demonstration sites. Protein could be used on an as needed basis. If these IPM demonstration tests produce significant positive results and confirm the efficacy of integration of sanitation, bagging, protein baits, male annihilation treatments, and parasitoids, expanded area-wide implementation should then be undertaken throughout the country.

15. Use of reduced risk pesticides, such as spinosad, in place of organophosphates should be a long term goal of fruit fly area-wide suppression programs throughout the African Region. Currently a SPLAT-MAT-ME spinosad product is being registered to be used in conjunction with GF-120. I will be reporting on this material during the next

year at scientific meetings (Vargas et al. 2000; 2003; 2005; 2008; 2010a; 2010b) and we hope to have it registered in California by the end of the year.

16. While in Senegal, as a guide on how to develop agricultural demonstration sites through a teamwork and cooperative approach through research, extension, and industry personnel, a short DVD presentation on the " the UH 1, 2,3 Approach" was presented to extension personnel. I also distributed Hawaii AWPM program brochures and recommended they be translated into French. Rudolph Putoa from French Polynesia already translated the most important brochure (Easy as 1, 2, 3) into French and I left it with Kemo. This approach should be pursued in several demonstration agricultural sites, specifically the mango production areas at Thiés and Ziguinchor. In Hawaii, an ARS area-wide IPM team has developed a successful AWPM program for four exotic fruit fly species, all of which are now present in Africa. These fruit flies have been devastating to Hawaiian agriculture, forcing growers to resort to almost weekly sprayings of chemical pesticides or even to abandon growing some crops all together. Estimates are that exotic fruit flies are costing Hawaii more than $300 million each year in lost markets for locally grown produce. That amount doesn't include potentially high value export markets, which Hawaii has forgone, because of fruit fly quarantine. In addition to developing many of the techniques used in the program, the ARS team has led and funded the partnership with the Hawaiian Department of Agriculture and the University of Hawaii to create the Hawaii Area-Wide Fruit Fly Integrated Pest Management Program (HAW-FLYPM), which has carried out an extensive effort to get Hawaiian growers to adopt the new technology. The depth of cooperation involved in bringing the technology to Hawaiian growers has been remarkable. The program works primarily through a combination of field sanitation**,** protein bait applications, male annihilation, and releases of sterile flies and parasites. The goal was to create a simple, effective, inexpensive program that growers would continue to use after ARS involvement ended. Growers who have been educated in the program have already been able to cut organophosphate pesticide use by 75-90 percent. By using the IPM program rather than indiscriminate use of chemical pesticides, growers have still reduced fruit fly infestation from 30-40 percent to less than 5 percent. The area-wide IPM program is also more environmentally friendly than conventional pesticide use. In addition to growers, the program is now also being taught to home gardeners whose gardens are major reservoirs for fruit flies. Monthly newsletters about the Hawaii program and additional information can be obtained at the website: www.extento.hawaii.edu/fruit fly. I highly recommend this approach to Senegal for control of fruit flies in mango (Mau et al 2007; Vargas et al. 2008; Pinero et al. 2009a).

17. Dr. Dennis Hannapel has requested "probit-nine" information for mango and I will have Dr. Peter Follett (Peter Follett@ars.usda.gov) send information to Dennis when I return to Hawaii.

18. Finally, Dr. Vaughan's research team is very knowledgeable, professional, and hard working. I genuinely admire their dedication to a very difficult and challenging project. Their efforts are very worthwhile and the mango project is extremely important economically to Senegalese farmers. In many instances mangos are their only source of income and nutrition. This is an opportunity for USAID to make an important

contribution to economic development within the country and needs to be supported over the long term. Larry's team has an excellent rapport with the farmers and I wholeheartedly support their activities. It was a pleasure to serve on this assignment.

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TRAVEL DETAILS:

I arrived at the Dakar, Senegal airport on Wednesday, March 17, 2010, where Larry Vaughan met me at 5:00 am. In the afternoon we traveled to meet with Kémo Badji at the Ministry of Agriculture Laboratories. We inventoried supplies received by the project. On Thursday morning we met with Aminata Niane Badiane, AG/NRM Specialist at USAID Headquarters in Dakar to discuss

additional procurement for the project. In the afternoon, Larry and I traveled to Thiés. From Thursday to Saturday (March 18-20) we visited mango orchards in the Thiés area as potential demonstration sites for *B. invadens* suppression. On Sunday we traveled by truck to Ziguinchor. On Monday and Tuesday we toured mango production areas near Ziguinchor to identify demonstration sites in the south. On Wednesday, I flew from Ziguinchor back to Dakar to meet with Dennis Hannapel and Robert Hanson at USAID Headquarters in Dakar to brief them on our activities over the last 8 days. On Thursday, March 25, 2010 at 1:00 am, I returned to Hawaii via Washington DC and Los Angeles.