FINAL PROJECT REPORT **YEAR**: 2 of 2

WTFRC Project Number: TR-05-508

Project Title: Development and Implementation of IPM Decision Aids

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Total project funding request: ***Year 1:*** $63,029 ***Year 2:*** $51,670

Budget:

Organization Name: WSU Tree Fruit Research and Extension Center
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Item	2007
Salaries	26,719
Benefits	9,715
Wages	9,320
Benefits	915
Equipment	0
Supplies	3,000
Travel	2,000
Miscellaneous	0
Total	51,670

Objectives:

1. Develop a web-based program that integrates location-specific weather data (from AWN and PAWS2 or uploaded from a user's own orchard) with insect and disease models and provides management recommendations along with a simplified database for pesticide recommendations (decision aid system, DAS).
2. Validate and implement models for peach twig borer, *Campylomma* bug, *Lacanobia* fruitworm and white apple leafhopper. Develop management recommendations for these pests and incorporate them into the decision aid system.
3. Develop a new codling moth model using historic weather data and a validation data set.
4. Develop large-scale sampling plans for codling moth larvae that can be used for quarantine purposes.
5. Beta test the DAS program with a small group of consultants to determine information needed and to optimize the user interface.

Significant Findings:

- The decision aid system was up and operating over the entire last season from March 5 onward. By the end of the season, we had 513 users.
- The codling moth model can and should be used in the future without a biofix. This eliminates a major source of confusion and error, and has no appreciable effect on model accuracy for adult emergence or egg hatch. It will be the standard model next year on DAS.
- The contaminated distribution for emergence of first generation codling moth is more accurate than the PETE model in our two test orchards; we will be evaluating its applicability to a wider range of orchards in the coming year.
- Large scale sampling plans to meet the Taiwan protocol can be modified so that the minimum distance between samples increases from 70' (current) to 109'; a 59.4% reduction in the number of samples necessary per acre, with no decrease in accuracy.
- Our sampling data also suggest that in roughly 80% of the orchards we surveyed, damage was primarily found on the edges.

Significant Progress:

Objectives 1 & 2.

No new progress since last report.

Objective 3. Develop a new codling moth model using historic weather data and a validation data set.

The data from 2007 was incorporated into our analysis. We found that there is still no significant advantage when using biofix with the standard codling moth model (known as the PETE model) for predicting adults or egg hatch over the first and second generations (Figs. 1 & 2). The major error in the PETE model using data from the TFREC and WSU Columbia View orchards is that the predictions are late in the range of ≈200-400 DD after biofix, then early from ≈ 500-1000 DD. Our correction for this factor increases the accuracy of the model in the first generation slightly when the biofix is used, but with the no-biofix model, accuracy is roughly two-fold better than the PETE model, irrespective of whether a biofix is used or not.

Under the new proposal that was recently funded, we will examine trap catch and weather data from other locations to see how well the contaminated distribution model works on data from orchards around the state before we implement the contaminated model into the DAS system. It

Fig. 1. Model failure rate for predicting adult emergence using standard (PETE) model and a modified model (Contaminated) either with or without the use of a biofix.

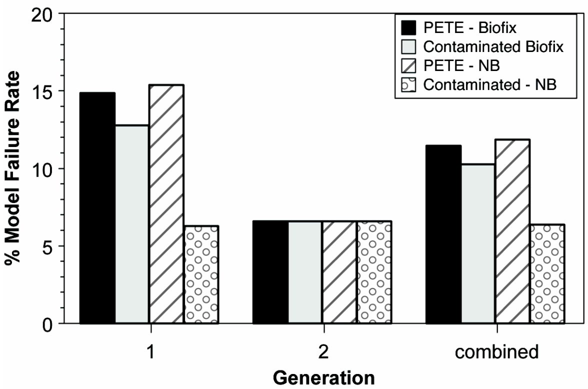
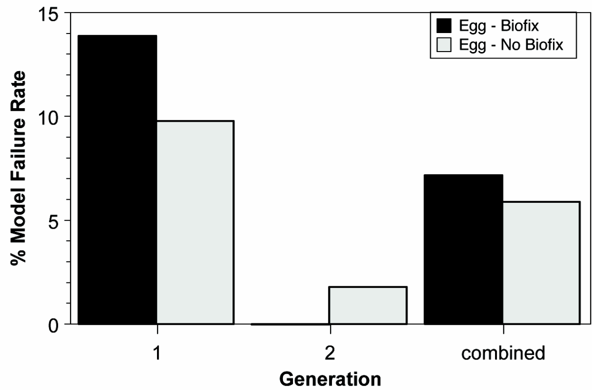


Fig. 2. Egg hatch model failure rate using biofix or not.



is possible that the TFREC site (which has the greatest amount of data) may show an emergence pattern that differs from other sites.

Objective 4. Develop large-scale sampling plans for codling moth larvae that can be used for quarantine purposes.

Over the past two years we have sampled a total of 32 orchards ranging in size from 3 to 27 acres (Table 1). In all, 5,879 trees were sampled and 60 half-fruit per tree were examined for codling moth damage (352,740 fruit). The number of samples per acre varied from 5.4 to 38.1 and averaged 22.4 trees per acre. The damage in our plots ranged from 0.1 to 5.1%, with an average across both years of 1.5%. We were aiming for orchards with higher damage than most grower orchards, primarily so that we could actually locate damage and be able to determine the spatial relationships. If we used extremely low level orchards, most of them would have to be dropped from any analysis because we would have found no damage.

The position of each tree was recorded with a GPS so that we could determine the exact position of the trees in relation to each other. The data were analyzed in several ways. First, we used geostatistics to determine the necessary distance between samples so that they were statistically uncorrelated. Sampling closer than this distance is inefficient; it requires more sampling effort, but gives no better estimates of the population level. We found that the estimates of this distance (called the "range" in geostatistics and Table 1) were similar between years. In 2006, the range was 100.9 feet and in 2007 it was 115.9 feet; over both years, the average was 109.2 feet. The current Taiwan protocol suggests that the distance between samples should be a minimum of 70 feet (=2.86 samples/acre), but our data suggest we only need 1.16 samples/acre, a 59.4% reduction in sampling density to achieve the same accuracy. According to Mike Willett (NHC), the current Taiwan work plan does not specify the sampling distance, but only that an assessment be done to evaluate the efficacy of orchard control programs. This can be done either on the tree or in the bin, prior to submitting the lot for packing. This means that changing the field sampling protocol next year does not require new negotiations with Taiwan; however, USDA/APHIS must review and approve the altered protocol.

The second analysis was to evaluate the average CM infestation level in a an orchard to the peak infestation level. The reason for this is to provide users with an understanding of why the mean infestation level in an orchard needs to be extraordinarily low to meet the Taiwan protocol. We found that there was a significant regression between maximum damage found on any one tree in an orchard and the average orchard wide damage level (max damage=3.6 + 6.5 × mean damage, r^2=0.76). This suggests that, on average, if your orchard has 0.2% average damage, it would be likely that you would find a tree in there that has up to 4.9% damage. In fact, if you examine the orchard mean for orchards

Table 1. Summary of spatial analysis of CM distribution for 2006-2007.

Year	Orchard No.	range (ft)	spatial var	r^2	mean damage	max damage	orchard size	no. trees sampled	samples acre	loc of peak damage	Cultivars
2006	1	126	0.84	0.83	1.50	15	17	490	29	interior	mixed
2006	2	67	0.86	0.81	0.17	3.33	12	360	30	interior	Gala, Braeburn
2006	3	61	1.00	0.23	2.45	23.33	4	128	32	edge	Reds
2006	4	235	0.70	0.98	1.82	13	5.6	169	30	edge	Reds
2006	5	58	1.00	0.61	0.16	3	12.8	300	23	edge	Reds
2006	6	50	1.00	0.42	0.25	4	4.3	163	38	both	Reds
2006	7	42	1.00	0.15	0.17	5	8.8	326	37	edge	Reds
2006	8	97	1.00	0.84	0.17	6.67	3	96	32	edge	Fuji
2006	9	57	1.00	0.67	0.09	1.67	7.2	183	25	both	Fuji
2006	10	163	0.56	0.37	0.69	5	7	141	20	edge	Reds
2006	11	78	1.00	0.33	4.51	26.67	23.5	328	14	edge	Reds
2006	12	65	0.99	0.42	0.31	3.33	12.3	317	26	both	Fuji
2006	13	156	0.64	0.99	4.15	33.33	4	121	30	edge	Gala
2006	14	66	1.00	0.40	2.59	11.67	5.2	96	18	both	Reds
2006	15	161	1.00	0.99	3.46	31.67	4.3	164	38	edge	Gala
2006	16	158	1.00	0.95	1.28	26.67	7.92	174	22	edge	Fuji, Reds
2007	17	88	0.999	0.652	1.82	41.94	11	171	16	edge	Gala, Fuji, Braeburn
2007	18	81	1	0.388	0.12	3.3	9	143	16	both	Gala, Braeburn, Golden
2007	19	77	0.86	0.623	0.62	13	5.6	87	16	interior	Reds
2007	20	114	0.998	0.837	0.18	5	12.8	276	22	edge	Reds
2007	21	160	0.996	0.698	1.82	23.33	4	44	11	edge	Reds
2007	22	68	0.997	0.854	0.77	16.67	4.3	95	22	interior	Reds
2007	23	104	0.999	0.914	0.82	5	4.7	71	15	interior	Gala
2007	24	70	0.999	0.968	0.77	6.67	14.4	215	15	interior	Gala
2007	25	208	0.753	1	0.69	16.67	6	165	28	edge	Gala
2007	26	123	0.976	0.994	0.37	3.3	4.9	92	19	both	Gala, Golden
2007	27	79	0.999	0.774	0.54	10	15	230	15	edge	Reds, Golden
2007	28	52	0.993	0.98	2.72	13.3	6	147	25	both	Fuji, Golden
2007	29	151	0.997	0.777	1.02	21.67	19	247	13	edge	Goldens
2007	30	143	0.923	0.95	3.08	23.33	27	147	5	both	Fuji
2007	31	144	0.947	0.896	2.49	20	6	128	21	edge	Fuji
2007	32	195	0.997	0.971	5.10	40	4.3	65	15	edge	Gala
	2006 average	102.5	0.91	0.62	1.48	13.33	8.68	3,556	27.84		
	2007 average	115.9	0.96	0.83	1.43	16.45	9.63	2,323	17.04		
	combined	109.2	0.94	0.73	1.46	14.89	9.15	5,879	22.44		

2, 5-8, and 20, the average orchard damage is 0.18% and the average maximum was 4.5%, very close to the predicted 4.77%. However, our sampling program measured *damage, not live larvae*, so the caution is that while the tree has a large amount of damage, it does not necessarily translate into rejection of that orchard; it just means that you are likely to come across a tree with much higher damage than average and that it needs to be closely examined for the prescence of live larvae.

The third analysis was simply to look at where the highest damage tended to occur. We classified each of the orchards as either: (1) peak damage mostly in the interior of the block, (2) peak damage mostly on the edge of the block, or (3) peak damage occurring in both locations. Of our 32 orchards, 18 were classed as having the majority of the damage on the edge of the block (56%), 6 on the interior (19%), and 8 in both locations (24%). Since peak damage occurs on the edge in the majority of orchards, it would be reasonable to suggest that the 8 orchards with peak damage in both locations started as edge problems that moved inward, leading to an estimate of 80% of the problems coming from the edge of the blocks. This is likely because of migration from outside, poor spray coverage on the orchard margins, and lower concentration of pheromone in mating disruption plots. The peak damage on the edge of the block also suggests optimal sensitivity is obtained by at least initially sampling the orchard perimeter, then moving to the center.

Objective 5. Beta test the DAS program with a small group of consultants to determine information needed and to optimize the user interface.

Our beta user group met November 9 and discussed several issues. First, we will release several beta features to all users this year, including the Peach Twig Borer model, cherry powdery mildew model, and the ability for users to add their own weather data. In the latter case, we will require the users to read and approve a warning about weather station calibration, location, and maintenance and how that may affect the quality of the predictions.

The beta group also strongly recommended that we proceed with a way of evaluting past pest control actions. The group gave us feedback on what they wanted in this regard, including a flow chart to help determine the various factors that can lead to control failure. We will investigate the best way to implement those requests and have a feature in beta this coming season.

We also received a request to give feedback on the status of the population on both a calendar and degree-day basis. These changes will be relatively minor and should be possible for all users this coming season.

It is also likely that we will have to grow the beta group slightly this coming season. The users at the meeting gave little feedback on the disease models and we will target a couple of people specifically for that area to help round out the group. We may also have to replace several members who did not provide any feedback over the past year.