Assessment of Hand-applied Codling Moth Pheromone Dispensers – 2001

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There has been conflicting information provided to growers and crop consultants relative to the pheromone release behavior of hand-applied codling moth dispensers. In an attempt to provide an unbiased assessment of these dispensers the Tree Fruit Research and Extension Center initiated a project to evaluate the pheromone release characteristics of different dispensers as they aged throughout the growing season.

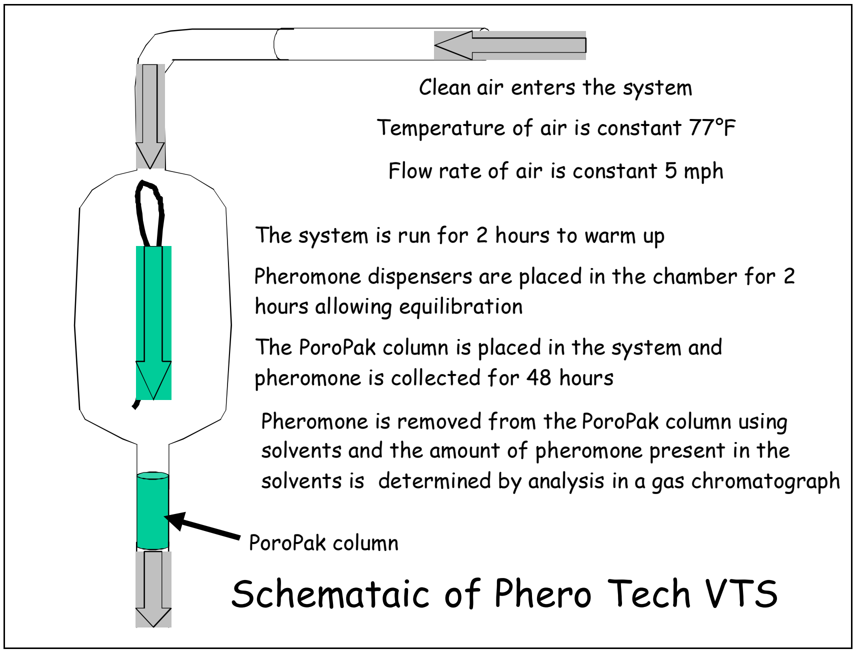
Methods: There were three methods used to evaluate the pheromone release from 5 different kinds of dispensers: gravimetric (weighing), volatile pheromone trapping, and residual analysis.

1. **Gravimetric Method** – This method involved placing 25 dispensers of each kind in the field at the beginning of the codling moth flight period. These dispensers were clipped onto a line that ran through the canopy of an apple orchard at the TFREC. Each week all 25 dispensers were taken to the laboratory and weighed on a sensitive scale. The weight of each dispenser from week to week was recorded and the average weight loss calculated per dispenser. Weighing was conducted from 25 April (day '0') to 27 September (154 total days).

2. **Volatile Trapping System (VTS) Method** – This method involved placing the different dispensers in the tree canopy as described above. However, in this method 5 dispensers of each kind were collected at approximately 30-day intervals, placed into mylar bags, sealed and placed in a freezer. Samples were sent to Phero Tech (British Columbia) for analysis using their VTS (see figure below). Clear filtered air of constant temperature (77°F) and flow rate (5 mph) is passed through the system for 1 hour to warm it up. The pheromone dispensers are taken from the freezer and placed in 68°F for 1 hour to warm up. The pheromone dispensers are then placed in the VTS for 2 hours to allow equilibration. The PoroPak columns that trap the pheromone are placed in the system and it is run for 48 hours. The PoroPak column is washed with solvents to remove the pheromone and the solvent containing the pheromone is injected into a gas chromatograph to determine the amount of pheromone captured. This system has been shown to capture 90% of the target material based on use of known internal standards used during the analysis.

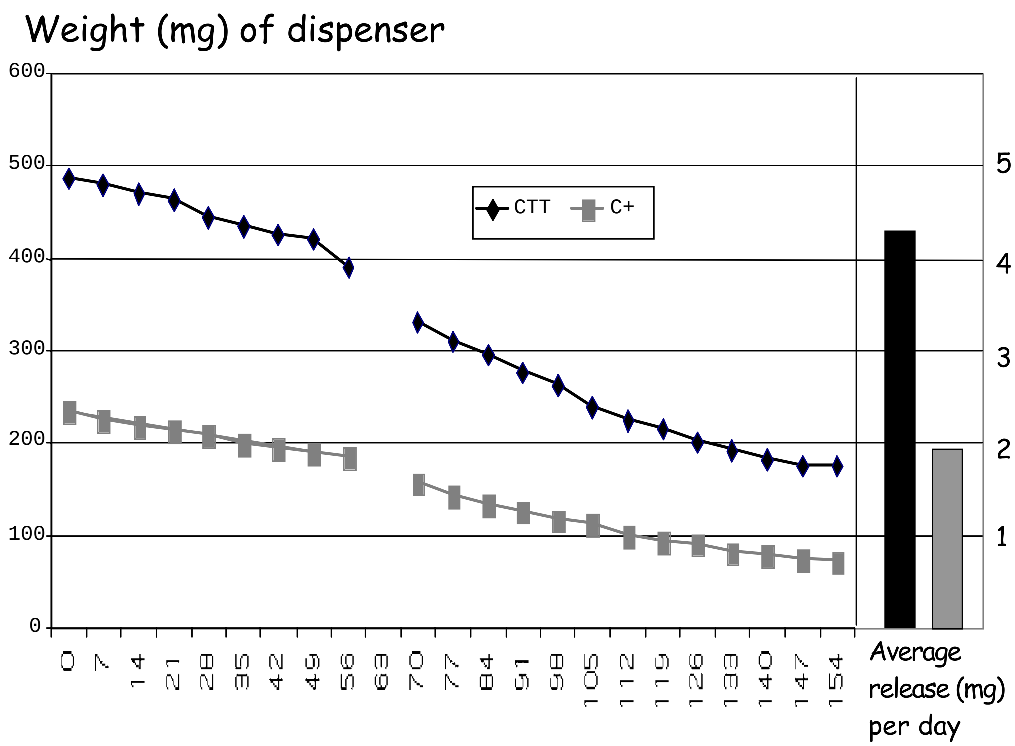
3. **Residual Analysis Method** – This method followed the same dispenser aging and collection procedures outlined above for the VTS method. At the end of the growing season dispensers were sent to the WSU Food and Environmental Quality Laboratory (FEQL) in Richland. Each dispenser was analyzed separately for pheromone components. The extraction procedures for different pheromone dispensers had been requested from the manufacturers and, where provided, were followed. Essentially all of the pheromone in a dispenser was removed by appropriate solvents or digestion of the dispenser. The amount of pheromone was then determined for each dispenser using a gas chromatograph. This system was 97-100% efficient in the recovery of target chemicals based on internal standards used during analysis.

Diagram of Volatile Trapping System (VTS)



Results and Discussion

Gravimetric Method – This method seemed viable only for the Isomate products and possibly for the NoMate product. The weighing of the Disrupt and Checkmate products showed highly variable results indicating that these dispensers are likely absorbing liquid or somehow gaining weight over time. The weight loss of the Isomate C Plus and Isomate CTT show a gradual decline over the period with a slightly lower rate loss towards the end of the season. Both dispensers show that there is pheromone, or some component of the original formulation, left at the end of the season.



Volatile Trapping System Method – This method analyzes the active ingredient of the pheromone dispensers, codlemone. It gives a relative comparison of the amount of codlemone released per dispenser type of different ages. Data are shown as the calculated codlemone released from a dispenser in mg per day. This is based on a 48 hour collection period under constant temperatures so cannot be directly compared to other methods used to analyze dispensers. The VTS is a dynamic system; that is, it shows the release rate of a dispenser of a certain age under a set of conditions and not the amount of pheromone left in the dispenser.

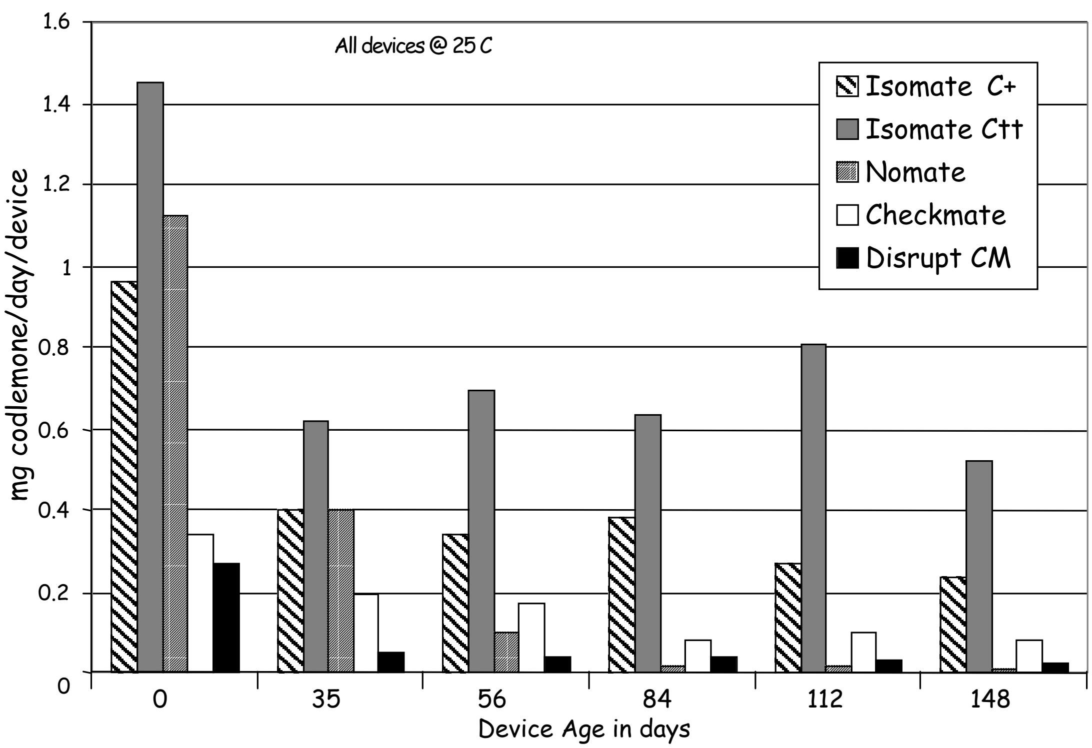
Estimated release of codlemone from each dispenser type of shown age.

	Calculated mg of codlemone released per dispenser over 24 hours				
Day	Isomate C+	Isomate CTT	NoMate	Checkmate	Disrupt CM
0	0.96	1.45	1.130	0.34	0.27
35	0.40	0.62	0.400	0.20	0.048
56	0.34	0.69	0.100	0.17	0.044
84	0.38	0.64	0.017	0.08	0.040
112	0.27	0.81	0.014	0.10	0.031
148	0.24	0.52	0.007	0.08	0.026

Several of the dispensers exhibit a burst effect where they release a high rate of codlemone from the day '0' dispenser. The Isomate CTT dispenser has the highest release rate of all dispensers tested. Its release rate is about double that of the Isomate C Plus dispenser; this is expected since the technology of the dispensers is the same and the Isomate CTT dispenser is designed to release twice as much pheromone per dispenser as the Isomate C Plus dispenser. The release rate for the Isomate C Plus dispenser declined slightly in the last two evaluations compared with the day 35, 56 and 84 evaluations. This could reflect a lower amount of pheromone remaining in the dispenser on these dates.

The NoMate day '0' dispenser had a release rate slightly higher or similar to the Isomate C Plus dispensers on day 0 and 35; however, on subsequent days the NoMate dispenser showed a very low release rate suggesting it was running out of pheromone. The Checkmate dispenser had a lower release rate compared to the Isomate C Plus dispenser on all sample dates. There is some concern that the arrangement of this dispenser in the VTS could have blocked or inhibited pheromone release from the Checkmate dispenser. Regardless this dispenser did show consistent release of pheromone at all sample periods, though at declining rates over time. The Disrupt CM dispenser showed a release rate similar to the Checkmate dispenser on day 0. On subsequent sample dates the release rates were consistent but low.

Codlemone release rate for five dispenser types (mg/day)



The VTS provides a relative comparison of the release rate of codling moth pheromone from dispensers of different ages in a dynamic environment. The one main concern we have about the

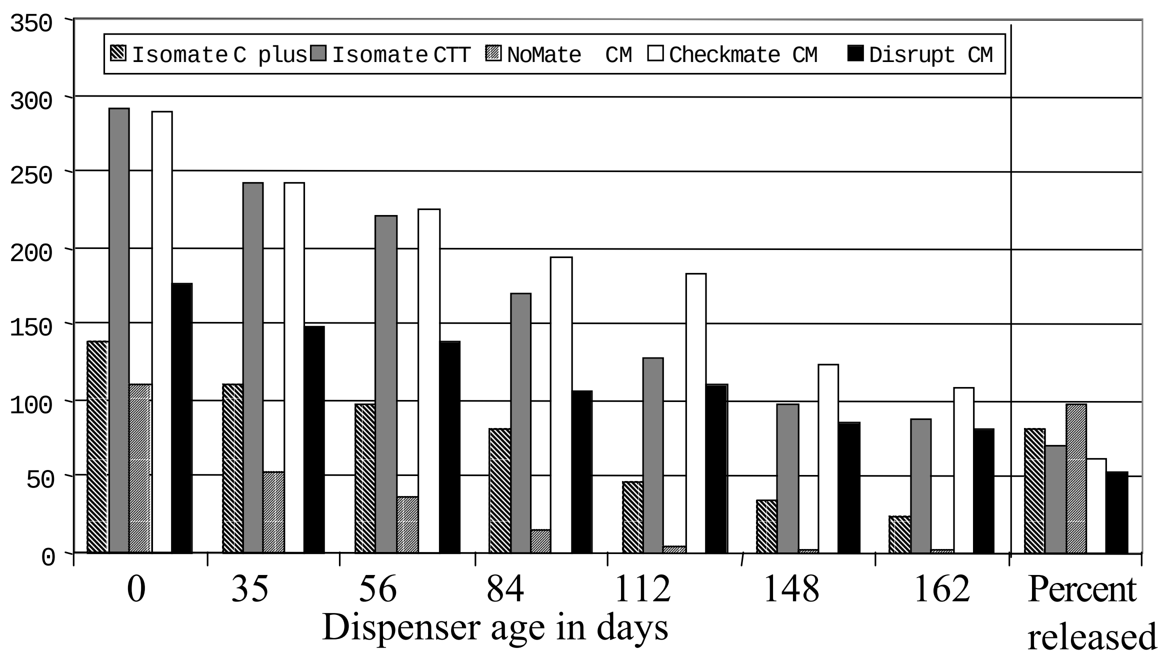
VTS method used in 2001 was the combining of 3 dispensers into the same VTS chamber. In order to trap sufficient pheromone and to average the variation from dispenser to dispenser, three dispensers of each type were placed into the VTS under controlled conditions. An important assumption of the VTS method is that every dispenser type be subjected to the same air flow characteristics to ensure an equal chance for optimum pheromone release under the conditions. The positioning of dispensers in the VTS chamber could be critical if their spatial arrangement interfered in any way with their release of pheromone. Dispensers like the Isomate or NoMate are less likely to be influenced by spatial arrangements within the VTS system because of their size but Checkmate and Disrupt products could be. In the latter dispenser types pheromone release rates could have been inhibited if adequate air flow over the releasing surface was limited by the spatial orientation of dispensers in the VTS. Phero Tech has assured us that they feel the orientation of different dispenser types in the VTS did not interfere with pheromone release. However, to ensure that this is the case they are going to run some of the dispensers separately and in groups of 3 to determine if they obtain comparable release data.

Residual Analysis Method – This method seeks to extract all of the codlemone from the dispenser to determine the amount remaining after different ages. It can be assumed that the difference in the amount remaining at each time period is a measure of the amount of pheromone released. The day '0' amount should reflect the amount of codlemone in the dispenser as stated by the registrant on the label. All the information we obtained seems to be in accordance with labeling specifications. Most dispensers lost codlemone gradually over time. The Isomate C Plus and CTT dispensers had a similar pattern in the amount of codlemone remaining in the dispensers. However, there was a higher percentage of codlemone remaining in the CTT dispenser (30%) compared to the C Plus dispenser (17%). The NoMate dispenser released codlemone rapidly, with less than 50% remaining after 35 days; by the end of the first codling moth generation (ca. 84 days) only 14% remained, and 2% of the original amount was left by day 162. The Checkmate dispenser showed a residual codlemone pattern similar to the CTT dispenser through day 56, but thereafter showed a higher residual content and by day 162 was still retaining 38% of the codlemone. The Disrupt CM dispenser showed the most variable results. The information on days 84 and 112 reflect this variability so that the average residual content was actually higher on the longer aged dispensers. This dispenser was also the least efficient at releasing codlemone, still retaining 46% on day 162.

Average amount of codlemone remaining in the dispenser (mg)

	Average amount (mg) of codlemone remaining per dispenser				
Age of dispenser (days)	Isomate C plus	Isomate CTT	NoMate CM	Checkmate CM	Disrupt CM
0	140.43	292.78	110.58	289.17	176.30
35	111.50	243.68	54.09	243.14	148.75
56	96.66	220.52	38.16	226.90	139.24
84	82.29	171.47	15.07	194.56	106.64
112	46.62	128.31	5.35	184.90	109.72
148	35.47	97.32	2.35	123.99	87.47
162	24.45	88.34	1.7	108.81	81.10
% released	**83**	**70**	**98**	**62**	**54**

Ave. mg codlemone remaining in the dispenser



The desired release characteristic of a pheromone dispenser is termed a "zero order" release. This is where a constant release rate of pheromone would occur over time until the dispenser is depleted. Pheromone dispenser manufacturers have been attempting to achieve this kind of release and many dispensers at least approximate a "zero order" release behavior.

Many factors influence the release of pheromone from a dispenser. The hand-applied dispensers are all passive release devices and the rate of release of pheromone is governed to a great degree by the temperatures the dispensers are exposed to. In general, the release rate of pheromone from the dispenser increases with higher temperatures. There needs to be a balance between making a dispenser that will release enough pheromone to provide effective mating disruption and having one that lasts the entire season, which seems to be the goal of all current hand-applied dispenser manufacturers.

This report summarizes information only on the characteristic behavior of different hand-applied dispensers in releasing codlemone. In and of itself the release behavior of pheromone from a dispenser does not state whether it will be efficacious or not. With our current understanding of codling moth mating disruption, efficacy is based on having some threshold amount of pheromone present in the orchard that limits the ability of males to find females, thus reducing the potential of the population in that orchard to increase. The information presented on different dispensers must be taken into consideration with the recommended number of dispensers used per acre as a full rate. In this way one can fairly assess the relative amounts of pheromone being released per acre by different aged dispensers and gain some understanding of the potential of each dispenser to negatively impact the target population.

It seems clear that the gravimetric measure of pheromone release only fits the Isomate C Plus and CTT products as a reliable though crude method of estimating pheromone release over time. The weight loss from these products reflects the total amount of product lost from the dispensers. Because the residual analysis of these dispensers showed that the three components identified on the label are released proportionally over time it can be assumed that a gravimetric measure gives a good approximation of the amount of codlemone released. We would not recommend weighing as a means of estimating pheromone release from other dispensers.

Because we have some questions about the VTS method and are continuing to examine its utility in estimating pheromone loss from individual dispensers we are not putting too much credence on its results except where it seems to agree with the residual analysis method, which it did in almost all cases, in a relative sense.

Using the residual analysis method we can determine a release rate for the first codling moth flight, from day 0 to 84, and the second flight, from day 84 to 161, for each dispenser type. Then by using the recommended rate of dispensers per acre based on the label we can at least estimate the amount of pheromone released per acre during each codling moth flight. In the table below the values have been calculated for each dispenser type from residual analysis data. All dispensers release between 14 and 38 grams of codlemone per acre in the first flight, again assuming all are used at full label rates. If it requires 10 grams of pheromone per acre to achieve suppression of codling moth then all dispensers would be expected to work well. In fact, even if some dispensers were used at half rate there would be sufficient pheromone to achieve adequate control. Results for the second flight are different from the first. The range of codlemone released was about the same, 5 to 23 grams, but most dispensers released less pheromone. This was especially true for the NoMate and Disrupt dispensers. Again if we use an arbitrary value of 10 grams of codlemone as representing a threshold rate for efficacy, two of the five dispensers would not meet the criteria. In addition, only one of the dispensers would provide enough pheromone if used at half-rate.

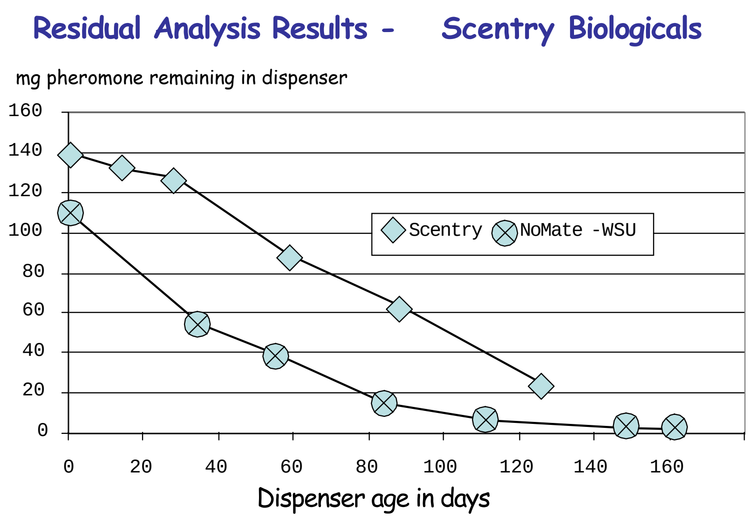
	Estimated grams of codlemone released per CM flight				
CM generation	Isomate C Plus	Isomate CTT	NoMate CM	Checkmate CM	Disrupt CM
dispensers per acre	400	200	400	200	200
1st gen	23.25	24.26	38.20	18.92	13.93
2nd gen	23.14	16.63	5.35	17.15	5.11

This discussion is hypothetical in the sense that as scientists we do not know the amount of codlemone required to suppress codling moth populations below damaging levels with pheromone treatments. Certainly the amount of pheromone required will vary depending on the codling moth population, site, and management approach. However, these are the considerations one should be using when selecting a mating disruption product for use in their orchards.

The information provided here is only the first step in developing a pheromone product evaluation system that is as unbiased as we can make it and still provide the industry with information needed to make informed decisions about pheromone mating disruption products. We hope to continue the evaluations in 2002 with the cooperation of all pheromone mating disruption manufacturers and will provide the industry with the results in a timely manner this winter.

New Insecticides and Miticides for Apple and Pear IPM
WSU-TFREC Tree Fruit IPM Workshops – February 2002

Behavior of hand-applied dispensers – addendum to proceedings.
The discussion of hand-applied dispensers does not reflect concerns of Scentry Biologicals Inc. about the initial condition of the NoMate dispensers analyzed by WSU and reported in the workshop proceedings. We are certain that the NoMate dispensers used were from the 2002 production and have provided Scentry with the Lot #. The spirals were 'red' and prior to placing the dispensers in the field the package had not been opened. However, the '0' day load as determined by WSU, 100 mg per dispenser, was below the label rate, 120 mg per dispenser, and below the rate Scentry consistently loads their dispensers, 130 to 140 mg per dispenser. This discrepancy could have led to the results noted and reported in the workshop proceedings, namely a faster than "normal" release rate for the NoMate dispenser in the first part of the year and therefore a shorter effective life for the dispenser. Scentry has provided WSU with data from Washington on dispensers placed at different locations, and data from one of these sites in north-central Washington are reproduced here for comparison purposes.



Why did WSU observed the uncharacterisitc pheromone release behavior from the NoMate dispenser based on the residual analysis and volatile trapping system analysis? Scentry feels that the kind of release characteristics WSU observed would have occurred because the dispensers were exposed to inappropriately high storage temperatures that caused the pheromone to migrate from the dispenser interior to the exterior. Then when the dispenser was exposed to the air the pheromone on the surface evaporated rapidly, certainly faster than Scentry's data shows, and continued to evaporate faster than normal, emptying the dispenser sooner than expected. If indeed this is what happened it is a good lesson for us all to learn. In 2002 WSU will evaluate dispensers prior to placing them in the field to make sure they meet label standards and the registrant's own expectations on pheromone loading rates. Distributors should learn the importance of proper storing of products like pheromone dispensers, as improper storage could have affected any of the hand-applied dispensers in a similar manner.