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Sampling Guidelines for Persea Mite in California Avocado Orchards

There are several non-native plant-feeding mites present in the California avocado system. These include the avocado brown mite (*Oligonychus punicae*), six-spotted mite (*Eotetranychus sexmaculatus*) and persea mite (*Oligonychus perseae*) (Acari: Tetranychidae). Among these, persea mite is the most economically important foliar mite pest of avocados. Persea mite populations can cause substantial defoliation to avocado trees during the summer growing season and consequently increase the risk of fruit sunburn and yield reduction. Since its first detection in California in 1990, persea mite has been the focus of on-going spider mite control research in avocados.

Currently, California's integrated pest management (IPM) program for persea mite in orchards consists of predatory mite releases (e.g., *Neoseiulus californicus* [Phytoseiidae]), selective application of pesticides, and cultural practices that may reduce the likelihood of mite outbreaks (see Hoddle and Morse, this issue). However, improved monitoring and sampling guidelines that enable growers to accurately estimate mite densities and confidently implement management options in a timely

manner are still needed. We have been working to remedy this shortcoming and the results of our research on developing accurate sampling protocols for persea mite are presented here.

Mite Sampling and Action Thresholds

Pest management programs operate on two fundamental concepts: the economic injury level (EIL) and the action threshold (AT) value (see Pedigo et al. 1986). In the context of plant feeding mites, the EIL represents a critical density beyond which the injury caused by mite populations to host plants translates into economic damage. An approximation of EIL values can be obtained from comprehensive field experiments that study the relationship between crop yield and a series of mite infestation levels. The action threshold represents the density at which treatments are initiated to prevent growing mite populations from reaching the EIL. The AT values are lower than the EIL and take into account multiple factors such as mite population dynamics and the time delays that may be associated with deploying specific control options. Once mite densities exceed the AT, the impending losses incurred from mite feeding, if no action is taken, outweigh the costs of treatment. When this occurs, it would be appropriate to apply a control treatment (e.g., pesticide applications or natural enemy releases). When mite densities are below the AT, there is no need to initiate treatments because economic losses are unlikely to occur, and the cost of treatment is not warranted.

Practical pest sampling plans are crucial for integrating the AT and EIL concepts into successful management programs. A structured sampling approach would allow for orchards to be monitored by professionals who can accurately assess mite densities on leaves during the growing season. Unfortunately, there is no industry standard for monitoring persea mites in California which makes uniform assessments and comparisons of pest severity within and between orchards unreliable. Under the current monitoring approach, persea mite densities can assessed based on an examination of leaf damage (Hoddle 2009), references to historical mite problems in the orchard, and partial counts along the leaves (Machlitt 1998). The drawback of these sampling plans is that they do not provide specification as to the number of leaves/trees and manner of sample unit selection that is needed for making reliable persea mite evaluations in a block of avocado trees (see Hoddle and Morse this

volume for more on these sampling approaches). A sampling plan that addresses these issues is still needed.

A major challenge in developing mite sampling plans for application in commercial orchards is achieving a significant reduction of counting effort without sacrificing accurate assessments of the severity of mite infestations. To meet this need we developed sampling guidelines for persea mite for growers and pest control advisers that would be easy to implement in the field. These recommendations stem from rigorous statistical analyses of persea mite count data (>20,000 avocado leaves examined and >1,000,000 mites counted) collected from commercial orchards throughout southern California across several years (Li et al. 2012, DePalma et al. 2012).

Validation of these guidelines has consisted of intensive computer simulations with blocks of 200 x 200 avocado trees (DePalma et al. 2012). The results indicated that an average of 5-10 trees with 6 leaves per tree was needed to reach a reliable treatment decision. This implies that even for smaller blocks (e.g., 25 x 25, 50 x 50,100 x 100) a minimum sample size of five trees or more from each of which six mature leaves are randomly sampled from each tree, would be sufficient for making an accurate assessment of mite levels within that block. In addition, the results indicate that there should be a minimum separation distance of four trees between sampled trees to ensure that estimated densities are representative for the entire block of interest, not just a small section. This removes bias that can occur when sampled trees are too close together. Therefore, the greater the distance between sampled trees the better the estimates of pest densities will be.

The practical application of these new guidelines for sampling persea mites is that no counting of mites is required. Instead, leaves are examined for the presence or absence of mobile persea mite stages (not eggs) on the leaf undersurface. Next, an estimate of the mean mite density is calculated from the proportion of leaves infested with 2 or more mites (e.g., 10 infested leaves out 30 sampled would be a 33% infestation rate). One of the advantages of using these sampling plans is that they can be customized to allow for a combination of various action thresholds. For example, growers with varying tolerances to persea mite infestations may consider making treatments when an average of 50, 70, 90, or 100 mites per leaf (these densities can be used as action thresholds) is estimated by the no count method. These action thresholds may

be compatible with chemical and biological control strategies that individual growers are comfortable with. For chemical control, a suggested action threshold of an average minimum of 50 mites per leaf to a maximum average of 100 mites per leaf has been recommended from field work conducted by Maoz et al. (2011) in Israel. Future research is still needed to define the EIL and AT for the California avocado system. We have selected the lower threshold value of the available range, an average of 50 mites per leaf, because the lower range allows time to accommodate any re-sampling efforts and/or time delays in implementing pest management options.

However, should commercially available predatory mites be released, the action threshold should be set to a level with enough pest mites available as food so predators can establish on trees. Field work by Hoddle et al. (2000) indicates that effective seasonal control of persea mite populations is possible when predators are released when 50% and 75% of sampled leaves are infested with persea mite. Based on our sampling models, these infestations levels correspond to an action threshold of an average of 7-17 mites per leaf. In practical terms, releasing predators below this threshold range prevents predators from finding enough food to establish seasonally. On the other hand, releasing predators above the 7-17 mite threshold range does not guarantee that predators will act quickly enough to prevent significant persea mite feeding damage.

Persea Mite Sampling Guidelines

Persea mite populations are not uniformly distributed and this can be observed across various levels of the orchard. During the growing season some sections will experience high densities of persea mite while other sections appear to be devoid of mite populations. Even within sections, hotspots of highly infested trees in close proximity to each other can sometimes be found while other groups of trees farther away, but still in the same section, have lower mite levels. Furthermore, some leaves on infested trees will have hundreds of mites while other leaves will have no mites. Consequently, collecting leaves without the aid of an efficient sampling framework that accounts for the spatial variation in mite densities can lead to making incorrect assessments. For example, if the grower only samples highly infested trees (e.g., more than 50 mites/leaf) from a couple of neighboring trees in a block, an assumption will

be made that the entire block is highly infested when this may not be the case.

To obtain a representative leaf sample we propose using the "no counting approach." This new sampling framework stratifies (i.e., arranges) leaf collection into tiers of targeted sampling. Each level is defined by specific criteria derived from our statistical analyses and observations in avocado orchards. The first tier involves dividing the sampling of the orchard into blocks of avocado trees. These blocks are defined by natural boundaries such as picking trails or service roads. Trees in these blocks are likely to be under the same management schedule so it makes sense to consider them as a large sampling unit within the entire orchard. This gives the grower the advantage of first targeting blocks of trees that historically have had a problem with persea mite outbreaks. Even so, each tree block represents a sampling universe from which thousands of leaves can be selected. An exhaustive and thorough approach of sampling all leaves from all trees is not feasible. Therefore, additional levels of targeted sampling are needed at the tree-block level. The results of our analyses indicate that a minimum collection of 30 leaves per block is ideal for making a practical evaluation of mite densities. These 30 leaves are allocated among 5 trees (i.e., 6 leaves are taken from each of the 5 trees) separated by a minimum distance of 4 trees (i.e., every fifth tree is sampled). This spatial requirement overcomes the effect of sampling only a small section of the block where the grower might encounter a pocket of low or high mite densities.

In the subsections below we describe how the "no counting" approach can be implemented to make an assessment of persea mite levels in blocks of avocado trees. For each block that is sampled, recommendations are made regarding the 1) number and type of leaf samples, 2) the manner of leaf collection and processing, and 3) how to obtain an estimate of mite densities from the leaf inspection data. Finally, the assessments of mite densities made across blocks of trees can then be used collectively to make an informed decision on the type (e.g., chemical, biological control, no control needed) and extent of control (e.g., one block of trees, the entire orchard) needed for the orchard. During this decision making process, the recommended action threshold of 50-100 mites per leaf can used as a benchmark to identify blocks of avocado trees in the orchard with mite densities that are likely to lead to economic damage.

1. Leaf and Tree Selection

A minimum sample of 30 mature leaves (here 6 leaves will be selected from each of five trees, each of which is separated by a minimum of 4 trees) should be collected from a selected block of avocado trees. As each leaf is picked off the tree, it should be examined for the presence or absence of persea mite and this information is recorded on a data-sheet. Leaves should be examined and discarded in succession to prevent cross-contamination of mites between non-infested and mite infested leaf samples. Contamination is likely to occur if all leaves are picked and mixed together before examination. Under time constraints, the grower or pest control adviser may opt to first collect leaves and then inspect them together at a later time. If this is the case, leaves from each tree should be kept separate in paper or plastic bags and stored in a cooler with ice packs to prevent the movement of mites from leaves onto bags. This "pick and bag" approach is not recommended. More details on the inspection process are presented in subsection 2, leaf inspection and pest identification.

Mature leaves that are hardened off and fully expanded should be collected because these leaves are more likely to be infested with persea mites. Sometimes fully expanded leaves may not available, especially when trees are flushing, and in these cases younger leaves can be selected. Leaf samples are stratified in such a way that six leaves are collected while walking around the perimeter of each tree (i.e., a total of 5 trees are selected from which a total of 30 leaves are picked). Selected trees should be separated by a minimum of at least four trees (i.e. sample every fifth tree at a minimum, greater separation is better) to obtain a representative snapshot of mite levels over the sampled block. Furthermore, no effort should be made to collect only mite infested or "clean" leaves. Instead, it is better to select leaves at random for examination to avoid making biased assessments that may result in an inaccurate decision to treat or not to treat.

It is worth noting that blocks of avocado trees vary in size. For this reason, growers and pest control advisers need to be familiar with the tree layout in an orchard beforehand to determine a sampling route that complies with the basic sampling guidelines described above. From our field experience the possibility of setting up a sampling pattern customized for each orchard should not be difficult since: (1) growers keep a record of the tree layout, and (2) both growers and pest control advis-

ers are familiar with the history of persea mite problems in the orchards they manage. These two experience factors will facilitate an objective sampling approach for first targeting blocks within orchards that have a history of persea mite problems. These historical "hot spots" may represent potential areas conducive to mite outbreaks during the later summer months and a source of mites that can spread via ballooning to uninfested areas of the orchard. Consequently, if there are hotspots with a history of severe persea mite infestations, the grower should target these first for sampling so treatments can be applied (if necessary) before this pest becomes a problem.

2. Leaf Inspection and Pest Identification

The entire undersurface of each collected leaf should be inspected in the field with a hand lens for the presence of persea mite. Areas where these mites are most likely to be found feeding and building nests should be examined, and include the mid-rib and lateral leaf veins (see the Hoddle and Morse article in this volume for more information on this). Leaves with zero or one motile persea mite are scored 0 (not infested) and leaves with two or more mites are scored 1 (infested). The scores can be recorded on a data sheet to calculate the proportion of infested leaves. With practice, the inspection of a leaf with a hand lens or optivisor should take no more than 30 seconds. As populations of persea mite build up, the scoring process becomes faster as mites are easier to find, and this reduces the overall sampling time. In general, sampling a batch of 30 leaves from five trees each separated by a minimum of four trees from a block of avocado trees can take approximately 15-35 minutes. An outline of the sampling procedure is shown in (Fig. 1).

Great effort should be made to avoid misidentifying persea mite during the inspection process as errors will lead to overestimating or underestimating mite densities in blocks of trees. Under field settings, a high magnification hand lens (20x) is necessary to differentiate between several groups of mites, both plant-feeding (e.g., spider mites, tydeids) and predaceous (e.g., phytoseiids, stigmaeids), that are present in the California avocado system (Fig. 2). To the untrained eye all of these mites can look the same due their small size. This is complicated by the fact that these tiny mites can be sometimes found feeding or resting under the dense webbing of persea mite nests. To distinguish the different species it is important to be familiar with the nuances of their color,

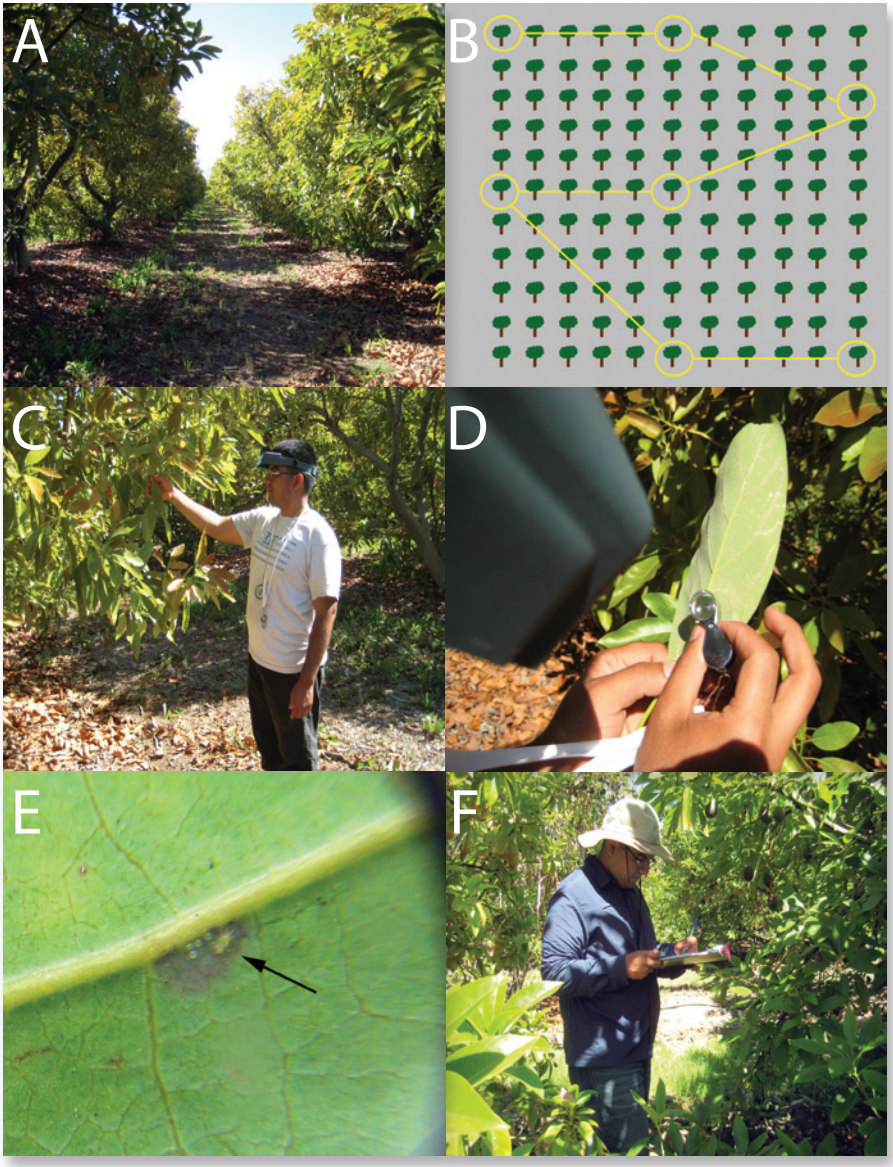

Figure 1. Outline for implementing the sampling guidelines for persea mite in avocado orchards: (**A**) A block of avocado trees is selected for inspection. (**B**) Diagram of the tree layout where trees have been pre-selected with a minimum distance of five trees to collect a representative sample of leaves. (**C**) Six mature leaves are collected randomly around the perimeter of each tree. (**D**) Individual leaves are inspected for the presence of persea mite. (**E**) View of the leaf undersurface through a hand lens; leaves with 2 or more persea mite presence are scored 1 and "clean" leaves with 1 or zero mites are scored 0. (**F**) The percentage of infested leaves determined from scoring is used to estimate persea mite densities in the sampled block. Several blocks of interest are sampled and an evaluation of mite densities in the orchard is made.

shape and behaviors. For this reason, sampling should be conducted at a point during early morning to mid afternoon when lighting is optimal. On cloudy days, it may be necessary to use a headlamp, or an optivisor, or hand lens with built-in LED lights.

Individual motile stages of persea mite can be recognized by their green-yellow colored bodies that are marked with dark spots and two conspicuous red dots that are the eyes (Fig. 2A). Usually the presence of dense webbing along the leaf veins and necrotic spots on the leaf undersurface are indicative of persea mite and these areas should be inspected carefully for live mites. Six-spotted mite (Fig. 2B) looks similar to persea mite but the webbing formed by the former tends to be less dense and it does not form circular nests. Avocado brown mite (Fig. 2C) is dark-brown in color and prefers to feed on the upper leaf surface; the feeding damage of this mite appears as a bronzing of the leaf. Incidentally, brown avocado mite can sometimes be seen walking across the leaf undersurface but its characteristic brown color makes it easy to recognize. Tydeid mites (Fig. 2D) are pale white to brown in color and do not have visible red dots (eyes) like persea mite. When prodded, tydeid mites can move relatively fast and they will sometimes appear to scurry away backwards. They can be found along leaf veins and sometimes they may occupy abandoned persea mite nests.

Phytoseiids (Fig. 2E) are tear-dropped shaped, have pale to golden-brown brown coloration and move really quickly when prodded. Phytoseiids that have recently fed on mites will have a characteristic colored "H" pattern on their dorsal shield. These beneficial predators are likely to be found walking along leaf veins or hiding in leaf-vein junctions. Stigmaeid mites (Fig. 2F) are beneficial predators and like persea mite they have two red dots as eyes. However, stigmaeids do not have black dots on their body, they move relatively slowly and their color is bright yellow to orange. At the moment we do not have a "no-counting" sampling plan available to estimate phytoseiid and stigmaeid mite densities but there is potential to develop a similar sampling process. If this sampling plan was available, growers would have the ability to make an assessment of densities of pest mites and beneficial predators during the summer when control of persea mite is needed.

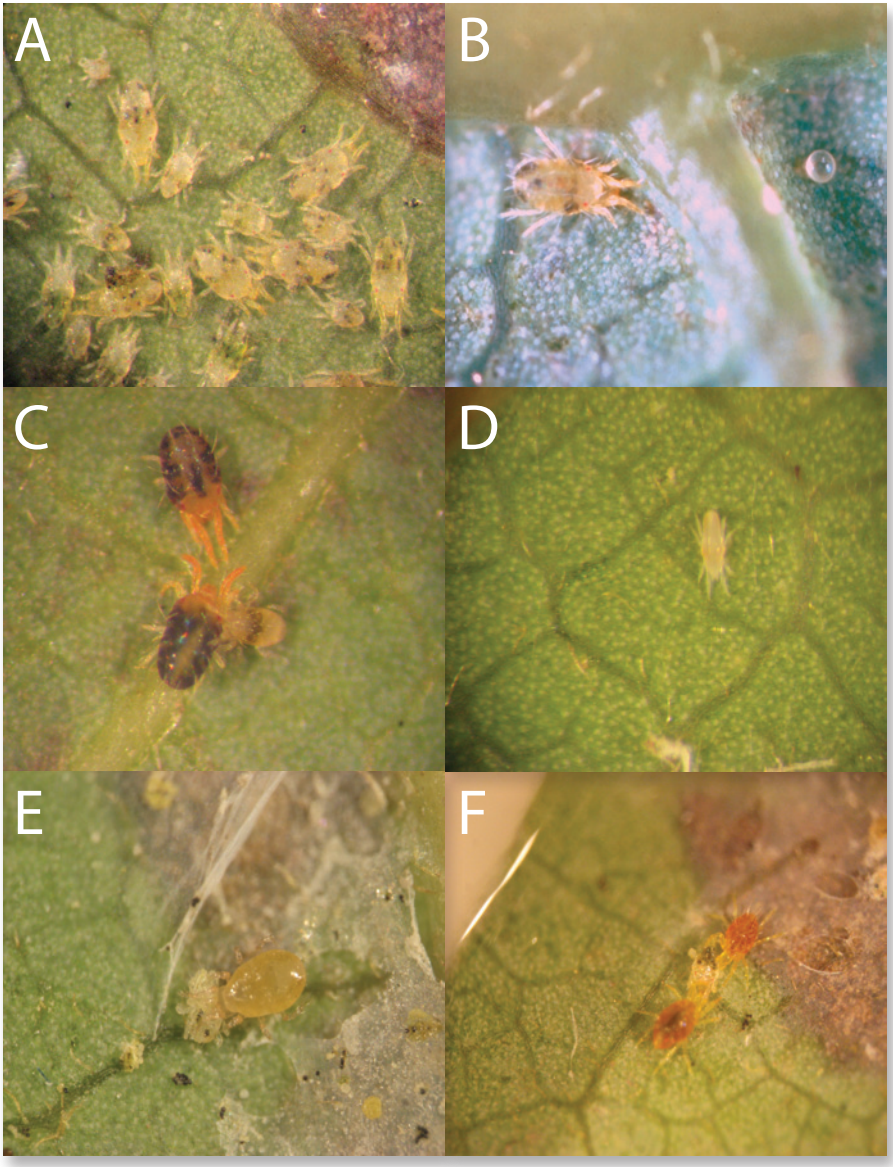

Figure 2. Mites likely to be encountered in the California avocado system: (**A**) A feeding colony of persea mites under the protection of their webbed nest. (**B**) An adult six-spotted spider mite. (**C**) Brown avocado mites being attacked by a predatory mite (*Neoseiulus californicus*). (**D**) A tydeid mite. (**E**) An adult phytoseiid mite feeding on persea mite near a webbed nest. (**F**) Two stigmaeid mites feeding on persea mite near a webbed nest.

3. Estimating Mean Densities and Making Recommendations

After all leaf samples from a block of trees have been scored, the proportion of infested leaf samples is calculated. This value is entered into a mathematical equation to estimate the mean density of mites. To expedite this process, growers and pest control advisers can use a printed table with corresponding pairs of mean-proportion values already calculated (see Appendix 1). For example, a proportion of infested leaves above 0.92 indicates that mite densities are above the 50 mites per leaf action threshold and that control for persea mite might be warranted in that block. In another block the estimated density might be 10 mites per leaf but these levels are relatively low and control may not be considered necessary at that particular site. Currently we do not have a fixed action threshold for California but the work from Israel suggests that an action threshold of 50-100 persea mites per leaf is reasonable.

In general, blocks with a history of persea mite problems can be targeted first to assess mite levels and prevent spread of the mite infestation. Ultimately the decision to treat with natural enemies, chemicals, or to delay control rests with the grower. If a block of trees has mite levels that are of concern to the grower but immediate control is not necessary, these areas should be re-sampled throughout the growing season to keep a record of mite populations as they may increase, decrease, or remain stable over time. Our current work based on data collected from a block of avocado trees over the past 10 years (Lara and Hoddle, unpublished) suggests that monitoring a block with a frequency of once to twice a month might be possible for detecting and reacting to building persea mite infestations in southern California avocado orchards.

Conclusions

Persea mite is an invasive foliar pest of avocados that has been present in the California avocado system over the past two decades. Chemical and biological control are part the persea mite pest management program but improvements in sampling methods are still needed to implement these control options in a timely manner. Current sampling strategies lack a structured framework to help growers assess mite densities without having to count mites. In response to this shortcoming, we have developed a "no counting approach" that relies on the proportion of infested leaves to estimate persea mite densities. In addition, we have worked on extensive sampling simulations that provide further

guidance on the number and manner of leaf and tree selection within an orchard. These guidelines take into account the spatial variation in mite distributions and can be used to estimate densities in individual blocks of avocado trees. Various tree blocks of interest are sampled independently and the estimated mite densities are used to make an informed pest management decision. We suggest using an action threshold in the range of 50-100 persea mites per leaf as a benchmark to consider treatment applications in a block of avocado trees and this strategy would be compatible with chemical control. Implementing biological control would require releasing predators when densities are above 7 mites per leaf to allow natural enemies to establish seasonally (see Hoddle and Morse in this issue for more information).

Figure 3. Comprehensive persea mite workshops held in June 2012: (**A**) Participants learned about persea mite biology, its invasion history, guidelines for implementing biological control and strategies to reduce the potential for miticide resistance in persea mite populations. (**B**) During the field component, participants learned how to use the "no counting approach" to estimate persea mite densities in blocks of avocado trees using provided hand lenses and data sheets.

As an extension to this work, we held field demonstrations (Fig. 3) in June 2012 (Santa Paula and Irvine) to train growers and pest control advisers on how to use the "no counting approach." The feedback we received was positive and results between users were consistent. Although we have made significant progress in designing a new sampling method for persea mite, additional work is still needed to streamline its application in California. Among these is the need to 1) refine the persea mite action threshold range with field studies to allow for more consistent orchard management practices, 2) continue to validate "no count" sampling guidelines in commercial orchards, and 3) develop a similar

"no counting" approach for evaluating persea mite predator densities in the field. The latter will help growers monitor the progress of biological control agents (natural or released populations or predators) during the growing season and a record of predator densities can be weighed against the need for using pesticides that might otherwise disrupt biological control of persea mite. Finally, there is also the possibility of facilitating user adoption of the "no counting approach" by developing a smartphone or tablet application that stores the presence-absence data and automatically calculates an estimate of persea mite densities. This would reduce the time spent in the field looking at tables and writing down information on data-sheets.

For additional information on persea mite biology and management information please visit www.biocontrol.ucr.edu.

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Appendix I

A combination of two sets of tables and a datasheet are shown below as part of the "no counting" persea mite sampling program developed for California avocados. The first set of tables provide calculations for the percent of leaves infested based on a five to ten tree sample with six leaves collected from each tree (i.e., 30-60 leaf collection). The second set of tables show the paired mean-proportion values for two leaf infestation scoring criteria: (1) at least one persea mite is present on a leaf or (2) at least two persea mites are present on a leaf. These mean-proportion values were calculated from complex mathematical equations that were used for statistical analyses.

In practice, a grower/grove manger/PCA will predetermine an appropriate leaf sample size (i.e., five trees and six leaves from each tree) for a block of avocado trees and score each sampled leaf as infested or clean. The minimum requirement based on our analyses is 5 trees with 6 leaves selected from each tree. Each sampled tree must be separated by a minimum of four trees. An example of a datasheet is provided to keep track of sample information so that a quantitative assessment of persea mite infestation levels can be made. Depending on the number of trees sampled, the first set of tables is used to determine the percentage of avocado leaves infested with persea mites. This value is then used in the

second set of tables to find the corresponding estimate of persea density (i.e., the estimated mean number of mites per leaf). The tables and data-sheet have been designed so that the grower/grove manager/PCA does not have to make any calculations other than scoring individual leaves as clean or infested.

Table Set 1: The tables show the calculations for the percent of leaves infested for a sample size of five to ten trees with six leaves collected from each tree. Trees and leaves are selected using the guidelines discussed in this article.

Trees Sampled: 5			Trees Sampled: 6		
No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves	No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves
1	30	3.33%	1	36	2.78%
2	30	6.67%	2	36	5.56%
3	30	10.00%	3	36	8.33%
4	30	13.33%	4	36	11.11%
5	30	16.67%	5	36	13.89%
6	30	20.00%	6	36	16.67%
7	30	23.33%	7	36	19.44%
8	30	26.67%	8	36	22.22%
9	30	30.00%	9	36	25.00%
10	30	33.33%	10	36	27.78%
11	30	36.67%	11	36	30.56%
12	30	40.00%	12	36	33.33%
13	30	43.33%	13	36	36.11%
14	30	46.67%	14	36	38.89%
15	30	50.00%	15	36	41.67%
16	30	53.33%	16	36	44.44%
17	30	56.67%	17	36	47.22%
18	30	60.00%	18	36	50.00%
19	30	63.33%	19	36	52.78%
20	30	66.67%	20	36	55.56%
21	30	70.00%	21	36	58.33%
22	30	73.33%	22	36	61.11%

Trees Sampled: 5			Trees Sampled: 6		
No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves	No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves
23	30	76.67%	23	36	63.89%
24	30	80.00%	24	36	66.67%
25	30	83.33%	25	36	69.44%
26	30	86.67%	26	36	72.22%
27	30	90.00%	27	36	75.00%
28	30	93.33%	28	36	77.78%
29	30	96.67%	29	36	80.56%
			30	36	83.33%
			31	36	86.11%
			32	36	88.89%
			33	36	91.67%
			34	36	94.44%
			35	36	97.22%

Tree Sampled: 7			Trees Sampled: 8		
No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves	No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves
1	42	2.38%	1	48	2.08%
2	42	4.76%	2	48	4.17%
3	42	7.14%	3	48	6.25%
4	42	9.52%	4	48	8.33%
5	42	11.90%	5	48	10.42%
6	42	14.29%	6	48	12.50%
7	42	16.67%	7	48	14.58%
8	42	19.05%	8	48	16.67%
9	42	21.43%	9	48	18.75%
10	42	23.81%	10	48	20.83%
11	42	26.19%	11	48	22.92%
12	42	28.57%	12	48	25.00%
13	42	30.95%	13	48	27.08%
14	42	33.33%	14	48	29.17%
15	42	35.71%	15	48	31.25%

Tree Sampled: 7			Trees Sampled: 8		
No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves	No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves
16	42	38.10%	16	48	33.33%
17	42	40.48%	17	48	35.42%
18	42	42.86%	18	48	37.50%
19	42	45.24%	19	48	39.58%
20	42	47.62%	20	48	41.67%
21	42	50.00%	21	48	43.75%
22	42	52.38%	22	48	45.83%
23	42	54.76%	23	48	47.92%
24	42	57.14%	24	48	50.00%
25	42	59.52%	25	48	52.08%
26	42	61.90%	26	48	54.17%
27	42	64.29%	27	48	56.25%
28	42	66.67%	28	48	58.33%
29	42	69.05%	29	48	60.42%
30	42	71.43%	30	48	62.50%
31	42	73.81%	31	48	64.58%
32	42	76.19%	32	48	66.67%
33	42	78.57%	33	48	68.75%
34	42	80.95%	34	48	70.83%
35	42	83.33%	35	48	72.92%
36	42	85.71%	36	48	75.00%
37	42	88.10%	37	48	77.08%
38	42	90.48%	38	48	79.17%
39	42	92.86%	39	48	81.25%
40	42	95.24%	40	48	83.33%
41	42	97.62%	41	48	85.42%
			42	48	87.50%
			43	48	89.58%
			44	48	91.67%
			45	48	93.75%
			46	48	95.83%
			47	48	97.92%

Trees Sampled: 9			Trees Sampled: 10		
No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves	No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves
1	54	1.85%	1	60	1.67%
2	54	3.70%	2	60	3.33%
3	54	5.56%	3	60	5.00%
4	54	7.41%	4	60	6.67%
5	54	9.26%	5	60	8.33%
6	54	11.11%	6	60	10.00%
7	54	12.96%	7	60	11.67%
8	54	14.81%	8	60	13.33%
9	54	16.67%	9	60	15.00%
10	54	18.52%	10	60	16.67%
11	54	20.37%	11	60	18.33%
12	54	22.22%	12	60	20.00%
13	54	24.07%	13	60	21.67%
14	54	25.93%	14	60	23.33%
15	54	27.78%	15	60	25.00%
16	54	29.63%	16	60	26.67%
17	54	31.48%	17	60	28.33%
18	54	33.33%	18	60	30.00%
19	54	35.19%	19	60	31.67%
20	54	37.04%	20	60	33.33%
21	54	38.89%	21	60	35.00%
22	54	40.74%	22	60	36.67%
23	54	42.59%	23	60	38.33%
24	54	44.44%	24	60	40.00%
25	54	46.30%	25	60	41.67%
26	54	48.15%	26	60	43.33%
27	54	50.00%	27	60	45.00%
28	54	51.85%	28	60	46.67%
29	54	53.70%	29	60	48.33%
30	54	55.56%	30	60	50.00%
31	54	57.41%	31	60	51.67%
32	54	59.26%	32	60	53.33%

Trees Sampled: 9			Trees Sampled: 10		
No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves	No. Infested Leaves	No. of Leaves Sampled	Percent Infested Leaves
33	54	61.11%	33	60	55.00%
34	54	62.96%	34	60	56.67%
35	54	64.81%	35	60	58.33%
36	54	66.67%	36	60	60.00%
37	54	68.52%	37	60	61.67%
38	54	70.37%	38	60	63.33%
39	54	72.22%	39	60	65.00%
40	54	74.07%	40	60	66.67%
41	54	75.93%	41	60	68.33%
42	54	77.78%	42	60	70.00%
43	54	79.63%	43	60	71.67%
44	54	81.48%	44	60	73.33%
45	54	83.33%	45	60	75.00%
46	54	85.19%	46	60	76.67%
47	54	87.04%	47	60	78.33%
48	54	88.89%	48	60	80.00%
49	54	90.74%	49	60	81.67%
50	54	92.59%	50	60	83.33%
51	54	94.44%	51	60	85.00%
52	54	96.30%	52	60	86.67%
53	54	98.15%	53	60	88.33%
			54	60	90.00%
			55	60	91.67%
			56	60	93.33%
			57	60	95.00%
			58	60	96.67%
			59	60	98.33%

Table Set 2: These tables show the calculated estimate of average persea mite densities per leaf from the percent of infested leaves obtained from Table Set 1 above. These estimates depend on the infestation threshold used for deciding whether or not a leaf is infested with persea mite. We recommend using an infestation threshold of at least two mites per leaf to score a leaf as "infested". In this case, an infestation percent value greater than or equal to 92 indicates there are, on average, more than 50 mites per leaf in the block sampled. The grower can use this information to make an informed treatment decision that is statistically-based. Additionally, we also provide tables for an infestation threshold of one mite per leaf to show the full extent of our analyses.

Threshold 1: at least one persea mite present	
% leaves infested	Estimated persea mites per leaf
0	0
10.00%	1
15.00%	1
20.00%	2
25.00%	2
30.00%	3
35.00%	4
40.00%	5
45.00%	6
50.00%	7
55.00%	8
60.00%	10
65.00%	12
70.00%	14
75.00%	17
80.00%	20
85.00%	25
90.00%	32
91.00%	34
92.00%	36
93.00%	38
94.00%	41
95.00%	45
96.00%	**49**
97.00%	54

Threshold 2: at least two persea mites present	
% Leaves Infested	Estimated persea mites per leaf
0	0
10.00%	1
15.00%	2
20.00%	2
25.00%	3
30.00%	4
35.00%	5
40.00%	7
45.00%	8
50.00%	10
55.00%	12
60.00%	14
65.00%	17
70.00%	20
75.00%	24
80.00%	29
85.00%	35
90.00%	45
91.00%	47
92.00%	**50**
93.00%	54
94.00%	57
95.00%	62
96.00%	68
97.00%	76

Threshold 1: at least one per-sea mite present	
% leaves infested	Estimated persea mites per leaf
98.00%	62
99.00%	76
99.10%	79
99.20%	81
99.30%	84
99.40%	87
99.50%	91
99.60%	96
99.70%	102
99.80%	111
99.90%	127
99.91%	129
99.92%	132
99.93%	135
99.94%	139
99.95%	143
99.96%	148
99.97%	155
99.98%	165
99.99%	182

Threshold 2: at least two per-sea mites present	
% Leaves Infested	Estimated persea mites per leaf
98.00%	87
99.00%	106
99.10%	109
99.20%	113
99.30%	117
99.40%	121
99.50%	127
99.60%	133
99.70%	142
99.80%	155
99.90%	176
99.91%	180
99.92%	184
99.93%	188
99.94%	193
99.95%	199
99.96%	206
99.97%	216
99.98%	229
99.99%	253

Datasheet: This is an example of a datasheet customized for a selection of five trees that can be used to keep a written record of each avocado leaf sampled and the estimated number of persea mites per leaf.

Site: Block: Orchard:			
Sample Date: Month/Day/Year			Time:
Infestation Criteria Used, 1 or 2 mites per leaf			
Sample every 5th tree, 6 mature leaves per tree (trees and leaves are selected randomly)			
Tree #	Leaf #	Infested Score (1 infested, 0 not infested)	Comment
	1		
	2		
	3		
	4		
	5		
	6		
	7		
	8		
	9		
	10		
	11		
	12		
	13		
	14		
	15		
	16		
	17		
	18		
	19		
	20		
	21		
	22		
	23		
	24		
	25		
	26		
	27		
	28		
	29		
	30		
% Sampled Leaves Infested:			
Estimated Persea Mite Density:			
Treatment Decision:			