Title of Project: Broad mite biology and management on blackberry

Progress Report, Research Proposal

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Objectives

1) To continue to describe the seasonal biology of broad mites and damage on blackberry
2) To determine the most effective combination of miticide application and/or release of a predator mite species for broad mite management on blackberry

Justification and Description

The goal for this study is to develop science-based management recommendations for broad mite, *Polyphagotarsonemus latus* (Banks) on blackberries.

In 2006, broad mites were first observed causing damage to the primocane-fruiting blackberry in Fayetteville, AR. Since 2013, broad mites have been confirmed as present and reducing blackberry yields in commercial field and high tunnel blackberry plantings in Arkansas, Illinois, Indiana, Maryland, North Carolina, South Carolina, Pennsylvania and Virginia. In 2015, growers across the Southern and Midwest regions continued to request broad mite management recommendations.

The first year of our Southern Region Small Fruit Consortium project number 2015-06 we described the seasonal biology of broad mites and noted when damage appeared on Prime-Ark® 45 blackberries in Arkansas, noted susceptibility of blackberry cultivars and breeding selections and identified efficacy of several miticides against broad mites. From 31 March 2015 on, we sampled biweekly to note changes in the densities of broad mites and predator mites on blackberries in several field and high tunnel plantings in Arkansas. The first broad mite eggs and motiles were detected on 26 May in a commercial field of Prime-Ark® 45 blackberries (Fig. 1). By mid-June, there were more than 15 eggs and 20 motile broad mites per leaflet, male broad mites had appeared and cupped foliar damage was evident. It was unknown if any blackberry selections or cultivars had resistance to broad mites. So I asked Dr. John Clark: What is the potential for genetic differences among the breeding program blackberries at the Fruit Station in Clarksville, AR for resistance to broad mites? On 13 Sept 2015, John answered as follows, "*I went thru all the advanced blackberry selections this afternoon Sunday Sept 13. I saw broad mite damage across all selections and varieties, with no exceptions in some degree of infestation. I could see no genetic differences among the genotypes, they seemed to all have damage, or more importantly none were without damage. It seemed worse in some areas of the field but was quite spread from one end to the other. And, it did seem to matter about age, as the 2015 planted plants had lots of damage also. So, with that many genotypes in the trial, and all showing damage, I don't think there is a genetic difference* *in susceptibility or any resistance as best I can tell. I provide this insight so that as you pursue new studies, you don't weigh too heavily on genetic differences and I don't think there is a high chance of resistance or differences in susceptibility thus am not sure it will be found. But that said, this is getting to be worse of a problem. The damage will impact performance of the plants next year, I have no doubt.*"

Currently, there are few management tactics recommended for broad mites on field or high tunnel grown blackberries. Our 2015 broad mite studies and those of Cloyd (2010) indicated that once plant damage was evident it was difficult to suppress broad mites. Cloyd (2010) recommended use of preventive measures including: removal and disposal of plants exhibiting broad mite symptoms and plants adjacent to symptomatic plants and apply miticides to prevent broad mite populations from spreading. Releasing predator mites has been recommended before a pest mite infestation appears, whereas if mite populations are already high, it may be necessary to spray a miticide before releasing predator mites. Note, Zeal (extoxazole) is moderately toxic to predator mites, whereas Agri-Mek (abamectin) is toxic to predators by direct contact but not long lasting.

There are several pesticides that controlled broad mites but none are registered for broad mites on caneberries. Peta (1988) reported that sulfur, oxythioquinox, avermectin, chlorpyrifos, and propargite provided broad mite control on lemons. Montasser et al. (2011) reported that Agri-Mek was the most effective against broad mite on peppers followed by liquid sulfur (Calcium polysulfide), canola oil (2% erucic acid rapeseed oil), whereas orange oil (D-limonene) and *Beauveria bassiana* showed moderate efficiency and Azadirachtin caused slight effect. Agri-Mek and Apta (Tolfenpyrad) significantly reduced numbers of broad mites on pepper (Stansly and Kostyk 2013). Magus (fenazaquin; later formulation called Magister) controlled broad mite on impatiens (Palmer and Vea 2012). In our 2015 study, broad mite numbers were significantly reduced for one week after an application of Agri-Mek, Apta or Magister but were only suppressed by M-Pede (potassium salt of fatty acids) and Zeal compared to untreated check (Table 1). After late-July, broad mites continued to cause foliar damage. An email by one blackberry grower in South Carolina reported control of broad mites for one month after applying Agri-Mek twice. He already had spider mite resistance to Zeal. Some specifics on usage restrictions of potential miticides for broad mites: Agri-Mek (28 PHI, 2 applications per season 21 days apart; new 2015 label for use on 13-07A caneberry sub-group only for post-harvest control of spider mites); Apta (Tolfenpyrad; 14 PHI, 2 applications per season 10 days apart only on ornamentals and stone fruit); Magister (12 hr REI; only labeled for non-bearing tree fruits and nuts; one application per year); and Zeal (0 PHI and 1 application per season; yearly Supplemental Label for use on caneberry for only spider mites). Miticides alone do not appear to adequately manage broad mites on blackberries, so they need to be integrated with releases of predator mites.

It is unknown which predator mite species would be the best biological control agent to release against broad mites in field blackberries. Phytoseiid predator mites (probably *Neoseiulus fallacis*) were only present from 31 March to 12 May, then dropped to zero by the time broad mites began to increase on blackberry terminals (Fig. 1). Possibly, the biology of *N. fallacis* was not synchronized with broad mite buildup in Arkansas or it was not able to feed and reproduce on broad mites. Other studies recommend releasing predator mites before broad mites establish (Cloyd 2010). On other crops, broad mite populations were reported controlled by *N. californicus* and *N. barkeri* (Fan and Petitt

1994; Peña and Osborne 1996), *N. cucumeris* (Weintraub et al., 2003), and *N. swirskii* (van Maanen et al., 2010). Arbico Organics (Oro Valley, AZ) online catalog states that *N. cucumeris* is more for thrips control. Our objectives will be to continue the biweekly biology study of broad mites on field Prime-Ark® 45 blackberries and determine the efficacy against broad mites of commercially available predator mites (*Amblyseius andersoni*, *N. californicus*, and *N. swirskii*) released alone or released before or after an application of Agri-Mek.

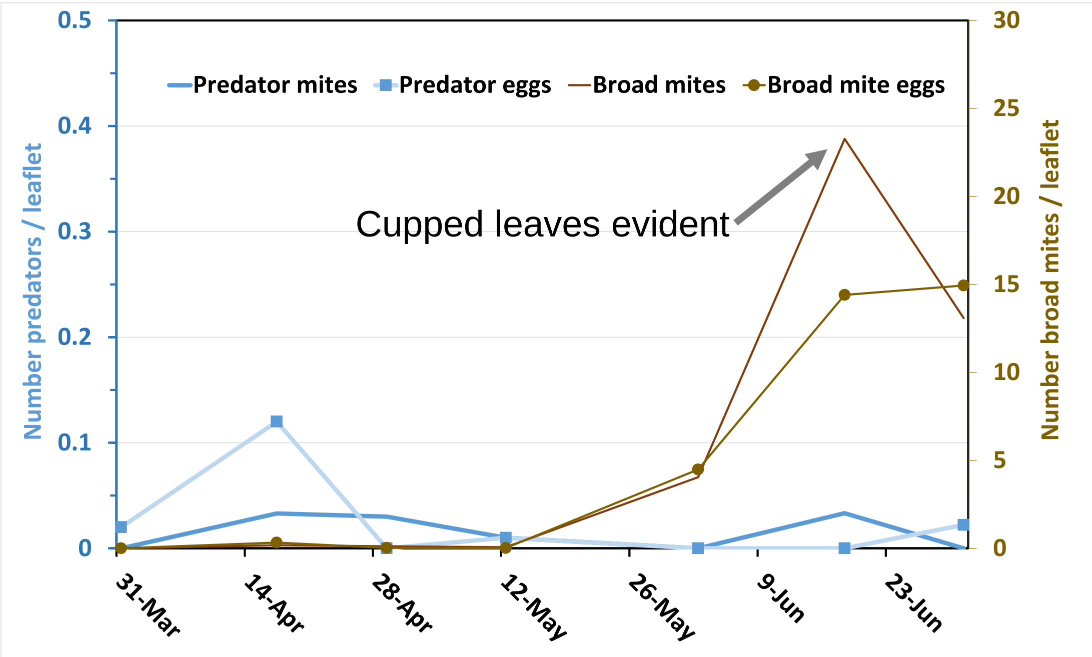

Figure 1. Seasonal changes in mean numbers of predator mites (*Neoseiulus fallacis*) and broad mites on terminal leaflets on Prime-Ark® 45 blackberry plants in Providence, AR (2015)

Table 1. Effect of miticides applied on 15 July to Prime-Ark® 45 blackberry plants on mean numbers of broad mites per leaflet in Providence, AR (2015)

	All Actives/leaflet			
Treatment/ Formulation	**15-Jul**	**22-Jul**	**29-Jul**	**8-Aug**
Agri-Mek	11.5a	0.5d	8.5a	13.5a
Apta	15.4a	1.5cd	11.8a	20.2a
JMS 1% (applied 7/22)	17.8a	18.3ab	12.7a	12.1a
Magister	13.6a	0.9d	6.7a	20.7a
M-Pede	10.7a	15.6b	17.8a	18.5a
Zeal	11.9a	12.2bc	21.1a	20.3a
Check	15.6a	27.0a	26.2a	21.7a

Mean values in same column followed by same letter are not significantly different (Tukeys t-test, $P < 0.05$)

Methodologies

1) To continue to describe the seasonal biology of broad mites and damage on blackberry

The seasonal biology study of broad mites will be repeated in 2016. Ten terminal leaflets from ten primocane-fruiting blackberries will be collected biweekly from blackberries in a high tunnel in Fayetteville, AR (8 mi round trip), at the Fruit Station in Johnson Co. (180 mi. round trip) and the commercial Prime-Ark® 45 blackberry planting near Providence, AR (240 mi round trip). A stereomicroscope will be used to count the number of broad mites (all stages) and other mite species per leaflet. There will be nine biweekly trips beginning when primocanes emerge in late-April through mid-August. Biweekly notes will be taken on when foliar damage begins and when fire blight-like symptoms (leaf death) appear.

2) To determine the most effective combination of miticide application and/or release of a predator mite species for broad mite management on blackberry

When broad mites are first detected in biology plots sampled under objective 1, we will order predator mites: *A. andersoni*, *N. californicus N. cucumeris,* and *N. swirskii* from Arbico Organics. In the laboratory, we will compare broad mite predation and oviposition rates of these four predator mite species using methods described by van Maanen (2010). Each predator mite species will be maintained with pollen on individual rearing plastic arenas edged with cotton kept moist on a wet sponge in a plastic tray containing water (Nomikou et al., 2003) and maintained at 23°C and 60 to 70% RH. Broad mite infested blackberry leaves will be collected from the field. Each predator mite species will feed for 2 days on one of these daily treatment diets of broad mites (repeated 4 times): 1) 15 adult females; 2) 15 motile immatures; 3) 15 eggs; and 4) predator mites with pollen but no broad mites (check). A fine brush will be used to transfer 15 female broad mites per day (treatment 1) or 15 motile immature broad mites (treatment 2) to mite-free leaves. One group of 15 females per leaf will be allowed to lay eggs for 1 day, females will be removed, number of eggs per leaf reduced to 15 eggs and one predator mite added (treatment 3). Infested leaves will be placed on a wet sponge arena in a plastic tray containing water. The numbers of broad mites consumed of each stage will be recorded after 1, 2, 3 and 4 days. Because oviposition rates are affected by the previous food source of adult predator mites, we will use oviposition data from the second to fourth days of the experiment only (Sabelis 1990). The two predator mite species exhibiting the best predation and oviposition rates of broad mites will be used in the following field study.

Before broad mites exceed 5 mites/leaflet from mid-May to early-June, a commercial field blackberry planting will be arranged and flagged in a randomized complete block design (3 replicates) of plots each with ten blackberry plants where each plot receives one of six treatments: 1) release predator mite species 1 only on five fully expanded terminal leaves on each plant in treatment plot; 2) release predator mite species 2 only on five fully expanded terminal leaves on each plant in treatment plot; 3) apply Agri-Mek miticide to plants twice at 21 day interval; 4) apply Agri-Mek miticide to plants followed two weeks later with release of predator mite species 1; 5) apply Agri-

Mek miticide to plants followed two weeks later with release of predator mite species 2; and 6) untreated check. At 0 (before treatment), 7, 14, 21, 28 days, and 2 and 3 months after treatment. Each plant in each treatment plot will be assessed as free or damage by broad mites. Concurrently, ten leaflets collected from 2nd fully expanded terminal leaves per plot will be bagged, labeled, returned to laboratory and a stereomicroscope used to count the numbers of broad mites and predator mites (all stages) per leaflet.

Analyses: The broad mite predation and oviposition data will be analyzed by analysis of variance (ANOVA) and compare means among predator mite species by Tukeys Honest Significant Difference. The weekly or monthly field treatment data will be analyzed as repeated measures ANOVA using PROC GLIMMIX with LSMEANS for mean separations (SAS 9.4).

Results

1) To continue to describe the seasonal biology of broad mites and damage on blackberry

Modified Methods: Samples of blackberry leaflets (5 to 20 newly expanded terminal leaflets) were collected and counts made weekly or biweekly of the number of broad mites (all stages) per leaflet from four locations: 1) five, 25 ft untreated plots in a one acre commercial Prime-Ark45® planting near Searcy, AR; 2) three, 10 ft untreated plots of blackberry breeding selections at the Fruit Substation in Clarksville; 3) twelve, 12 ft plots of primocane-fruiting blackberries (Prime-Ark45®, APF205, and Prime-Ark Traveler) in a high tunnel at the AAREC-Farm in Fayetteville, AR; and 4) three, 20 ft untreated plots of primocane-fruiting blackberries in a high tunnel at the SWREC in Hope, AR.

Results: Near Searcy, AR, the commercial Prime-Ark45® planting had counts exceed tentative action threshold of 5 broad mites per leaflet on 20 May and 9 June with two subsequent peaks of 26.8 and 49.9 broad mites per leaflet on 16 June and 7 July, respectively. Predatory mite (species being identified) counts peaked at 0.4 and 0.7 per leaflet on 22 June and 7 July, respectively, and appeared to cause a reduction in broad mite numbers. In early July, the grower pruned out broad mite-infested terminals and applied Agri-Mek to whole planting on 15 and 22 July. These sprays reduced numbers of broad mites and predatory mites to zero by 22 July (**Fig. 2**).

In Clarksville, AR, the broad mite numbers peaked at 80 actives per leaflet on 14 July, then dropped and remained below 20 active mites per leaflet into August (**Fig. 3**).

Inside the high tunnel in Fayetteville, AR, broad mites peaked at 7 actives per leaflet on 21 June, dropped to near zero by 28 June and began to increase on 14 July. Predatory mite numbers lagged slightly behind those of broad mites with peak of 1.2 per leaflet on 29 June and then stayed below 0.5 per leaflet through July (**Fig. 4**).

Inside the high tunnel at SWREC in Hope, AR, broad mites numbers exceeded threshold of 5 mites per leaflet from 10 June to late-July and was near zero by 5 August. Predatory mite numbers peaked at 1.6 per leaflet on 14 July and by 21 July dropped to and stayed below 0.13 per leaflet (**Fig. 5**).

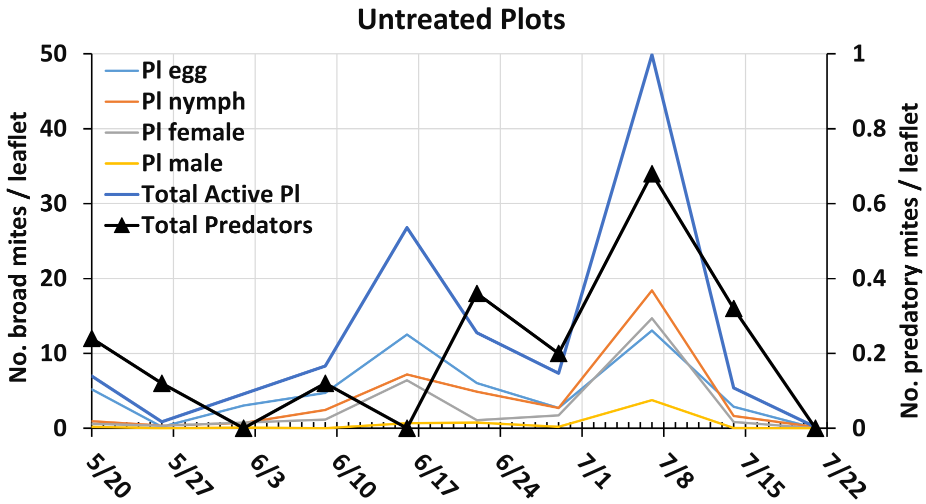

Figure 2. Mean (N = 5) numbers of broad mites by growth stage and numbers of predatory mites per newly expanded terminal primocane leaflet from a commercial Prime-Ark 45® blackberry planting near Searcy, AR (2016).

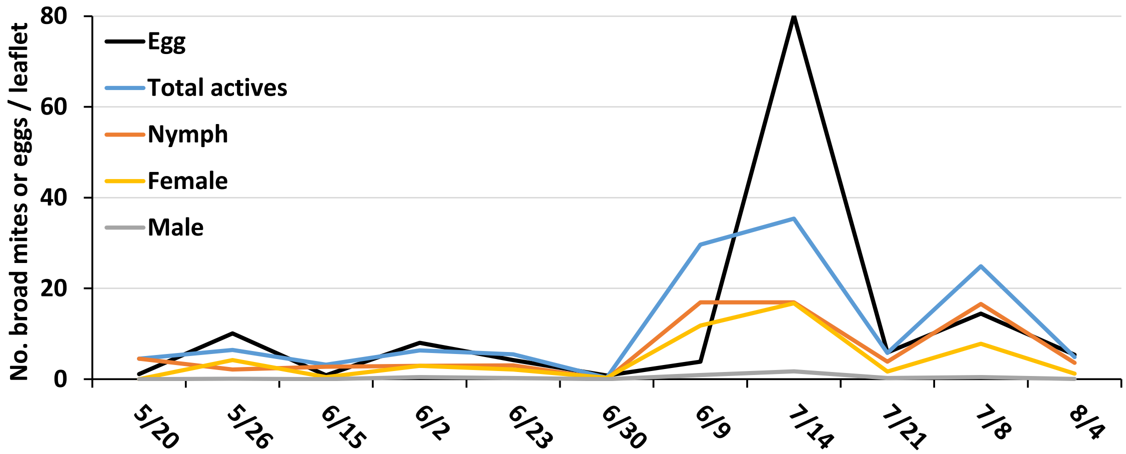

Figure 3. Mean (N = 3) numbers of broad mites of each growth stage per newly expanded terminal primocane leaflet on blackberry breeding selections at the Fruit Substation in Clarksville, AR (2016).

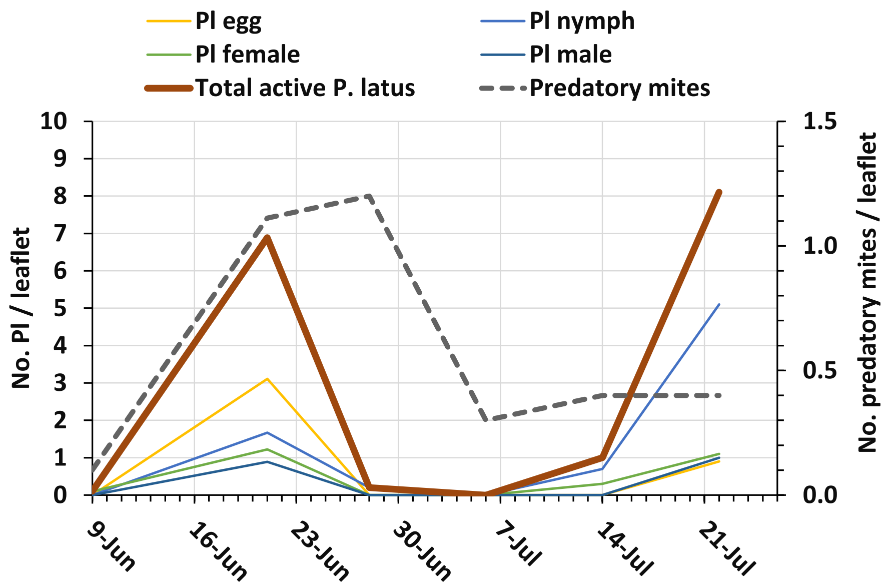

Figure 4. Mean (N= 12) numbers of broad mites (*Polyphagotarsonemus latus* or *P. latus* or Pl) of each growth stage and predatory mites per primocane-fruiting blackberry leaflet in a high tunnel at the AAREC-Farm in Fayetteville, AR (2016).

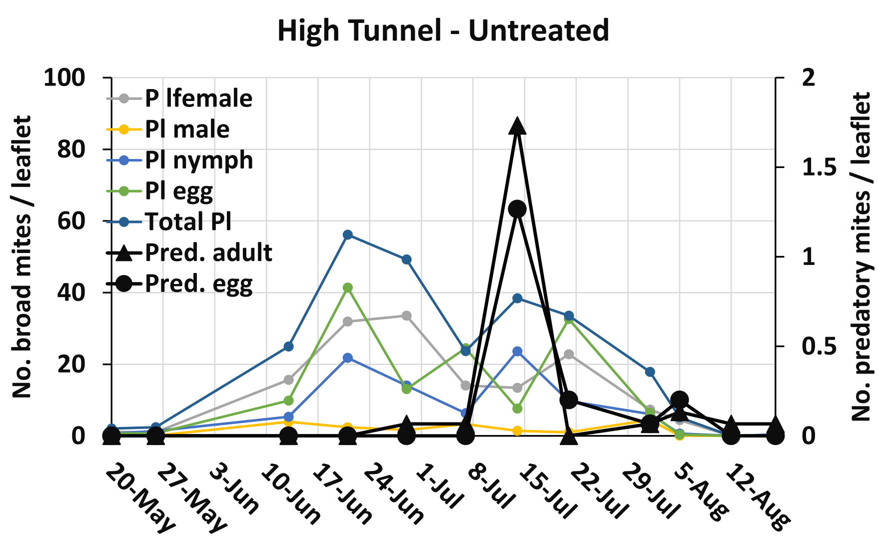

Figure 5. Mean (N = 3) numbers of broad mites (*P. latus* or Pl) of each growth stage and predatory mites (Pred.) per primocane-fruiting blackberry leaflet in a high tunnel at the SWEC-Farm in Hope, AR (2016).

2) <u>To determine the most effective combination of miticide application and/or release of a predator mite species for broad mite management on blackberry</u>

Modified Methods: Two separate trials were conducted sequentially at the SWREC in Hope, AR. In Trial 1 on July 21, 2016, 50 broad mite-infested blackberry leaflets were selected from primocanes of Prime-Ark Freedom blackberry plants in a high tunnel at the SWREC Hope AR. Underside of each leaflet was scanned to select leaflets with similar distributions of broad mite adult females, larvae and eggs. Distilled water moistened sponges were placed in petri dishes and covered with a chemwipe. Sponges were kept moist in dishes throughout observation period. Each leaf was dipped and swirled for 5 seconds in prepared treatment solutions, allowed to dry on paper towels for 30 minutes and placed underside up on moist sponge in petri dish. Treatments were arranged in 5 rows in a randomized block design (5 replicates) (**Fig. 6**). The petiole tip of each treated leaflet was cut off and covered with the moistened chemwipe on the moist sponge in the petri dish. Petri dishes were kept at room temperature for the duration of the experiment. At 24 and 72 hours after treatment, a stereomicroscope was used to aid in counting the numbers of mobile (live) or immobile (no movement in 5 seconds = dead) broad mite females, males, and larvae within a 1½ $inch^2$ leaf area on either side of each leaflet midrib. The total number of mites (mobile and immobile) were calculated and % of mites mobile and immobile were used for statistical analysis.

Results: In both trials, Agri-Mek, M-Pede, Microthiol and JMS Stylet Oil all caused > 90% broad mite mortality after 72 hours. After the first 24 hours, Agri-Mek and M-Pede caused > 95% broad mite mortality. In Trial 1 (**Table 2**), by 72 hours the most effective treatments (in order from highest to lowest percentage mortality) were: Agri-Mek (100%), M-Pede (97.7%), Microthiol 15lb (97.7%), Microthiol 10lb (97.55), M-Pede 1% (97.08%), and JMS Stylet Oil 2% (93.05%). In Trial #2 (**Table 3**), by 72 hours the most effective treatments was Agri-Mek (100%). Quillaja, and Penetrate (all rates) did not have a great effect until 72-hr after treatment. At 72 hrs, percentage mortality of broad mites by Agri-Mek and Quillaja 4% were similar at better than 83% mortality. Both rates of Penetrate (2 and 4%) and Quillaja 2% killed moderate percentage of broad mites (ranged from 65 to 72%) which were significantly greater than the 12% recorded for the water control. Microthiol (sulfur) did not kill mites immediately, but is effective after 72 hours. Microthiol, M-Pede, JMS Stylet Oil, Trilogy and possibly Quillaja might be a viable option for growers. More research needs to be done in larger field plots to determine best concentrations, timing, and rotations to be used against broad mites on blackberries. These trials identified some potential alternative formulations with different modes of action to use in a resistance management program against broad mites.

Figure 6. Experimental setup of treated blackberry leaflets in petri dishes

Table 2. Mean percentage mortality of broad mites recorded 24 and 72 hours after leaflets were dipped in treatment solution

Formulation/Rate	Rate/acre	% Mortality 24 Hrs	72 Hrs
Agri-Mek 2SC +	3.5 fl oz	100A	100.0A
Surf-king plus	0.5% v/v (NIS)		
M-Pede	2%	94.8A	97.7A
M-Pede	1%	98.8A	97.1A
Microthiol Disperss	15lb	72.1BC	97.7A
Microthiol Disperss	10lb	78.4A-C	97.6A
JMS Stylet Oil	2%	72.4A	93.1AB
JMS Stylet Oil	1%	37.2D	56.1C
Trilogy	1%	87.5AB	87.1AB
Trilogy	2%	65.1C	73.8BC
Water (control)	--	16.9E	10.1D

NIS = non-ionic surfactant
Means for a given treatment followed by same letter are not significantly different (Tukey's, P > 0.05).

Table 3. Mean percentage mortality broad mites recorded 24 and 72 hours after leaflets were dipped in treatment solution

Formulation	Rate/acre	% Mortality 24 Hrs	72 Hrs
Agri-Mek 2SC +	3.5 fl oz	99.5A	100.0A
Surf-king plus (NIS)	0.5% v/v		
Quillaja	4%	23.1BC	83.7AB
Quillaja	2%	42.5BC	65.3BC
Penetrate	4%	10.8C	67.3BC
Penetrate	2%	11.4C	71.2BC
Movento 240SC +	8 fl oz +	53.6B	54.9C
Succeed MSO	0.25 v/v		
Zeal	3 oz	31.8BC	47.8C
Water		3.4C	12.7D

NIS = non-ionic surfactant
Means for a given treatment followed by same letter are not significantly different (Tukey's, P > 0.05).

Modified Methods: At the Fruit Substation in Clarksville, AR, 10 ft plots various blackberry breeding selections (3 replicates) were treated with no predatory mites (control) or had one of four predatory mite species released on 20 May and 7 July 2016: *Neoseiulus* (= *Amblyseius*) *cucumeris* (12 and 10 sachets of 1000 mites per sachet with bran per plot); *A. andersoni* (12 and 10 sachets of 250 mites per sachet); *N.* (= *Amblyseius*) *swirskii* (12 and 10 sachets of 250 mites per sachet) and *N. californicus* (1000 mites in vermiculite). From 9 June to 22 July, weekly samples of ten newly expanded terminal leaflets were collected from each 12 ft long primocane fruiting blackberry plot (**Fig. 7**).

Near Searcy, AR, each of five 300 ft rows of a commercial Prime-Ark45® blackberry planting was subdivided into twelve, 25 ft plots between trellis posts with 25 ft buffer of plants between treatment plots. Treatments (5 replicates) included: 1) untreated control; 2) Microthiol (sulfur) applied on 7 and 20 May; 3 & 4) released on 20 May and 7 July either predatory mite, *N. cucumeris* or *N. swirskii*. The predatory mites released included: *N. cucumeris* (12 and 10 sachets of 1000 mites per sachet with bran per plot); or *N. swirskii* (12 and 10 sachets of 250 mites per sachet). From 20 May to 22 July, weekly samples of five to ten newly expanded primocane terminal leaflets were collected from each 25 ft plot (**Fig. 8**).

In Fayetteville, AR, a 180 ft L x 12 ft H x 25 ft W high tunnel had 5 ft sides and both ends covered with Teknet 80g mesh insect exclusion screen. The one row of blackberries planted inside was split into three, 60ft sections of blackberries: south section was Prime-Ark45®; middle section was APF205; and the north section was Prime-Ark Traveler. Treatments were no release (control) versus the release of one of three predatory mite species on 20 May and 8 July 2016: *N. cucumeris* (12 and 10 sachets of 1000 mites per sachet with bran per plot); *A. andersoni* (12 and 10 sachets of 250 mites per sachet); *N. swirskii* (12 and 10 sachets of 250 mites per sachet). From 9 June to 22 July, weekly samples of ten newly expanded terminal leaflets were collected from each 12 ft long primocane fruiting blackberry plot. From 9 June to 22 July, weekly samples of ten newly expanded terminal leaflets were collected from each 12 ft long primocane fruiting blackberry plot.

Results: At the Fruit Substation in Clarksville, AR, there appeared to be biological control of broad mites in plots with releases of *A. andersoni* (**Fig. 7A**) or *N. californicus* (**Fig. 7B**) with peak total broad mite counts of only 10.9 mites on 9 June and 6 mites on 14 July (*A. andersoni* plots) and 15.4 mites on 9 June and 14.4 mites on 14 July (*N. californicus* plots). In comparison, the no release (control) plots had the highest numbers of total active broad mites on 9 June (29.6 mites), 8 July (24.9 mites) and 14 July (35.4 broad mites) (**Fig. 7E**). There were slightly lower broad mite numbers in plots where releases were made of *N. cucumeris* (25.8 broad mites on 9 June and 26.6 broad mites on 8 July) (**Fig. 7D**) or *N. swirskii* (15 broad mites on 8 July and 15.4 broad mites on14 July) (**Fig. 7C**).

From 9 June to 14 July near Searcy, AR, the untreated plots (control) of Prime-Ark45® blackberries had newly expanded terminal leaflets that exceeded the action threshold of 5 broad mites per leaflet (**Fig. 8A**). The applications of Microthiol (sulfur) on 7 and 20 May (**Fig. 8B**) and releases on 20 May and 7 July of either predatory mite species, *N. swirskii* (**Fig. 8C**) or *N. cucumeris* (**Fig. 8D**), all delayed broad mite buildup above the threshold until 7 July when all exceeded 30 mites per leaflet (**Fig. 8B**).

At the AAREC-Farm in Fayetteville, AR, untreated plots without releases of predatory mites had higher broad mite densities on 9 and 21 June and 14 July than the three plots where predatory mites were released (**Fig. 9A**). Predatory mite densities were fairly similar across all treatments (**Fig. 9B**). However, predator mite counts were lower in the *N. cucumeris* release plots than other treatment plots which may have been attributed to similarly lower broad mite densities in those plots in June.

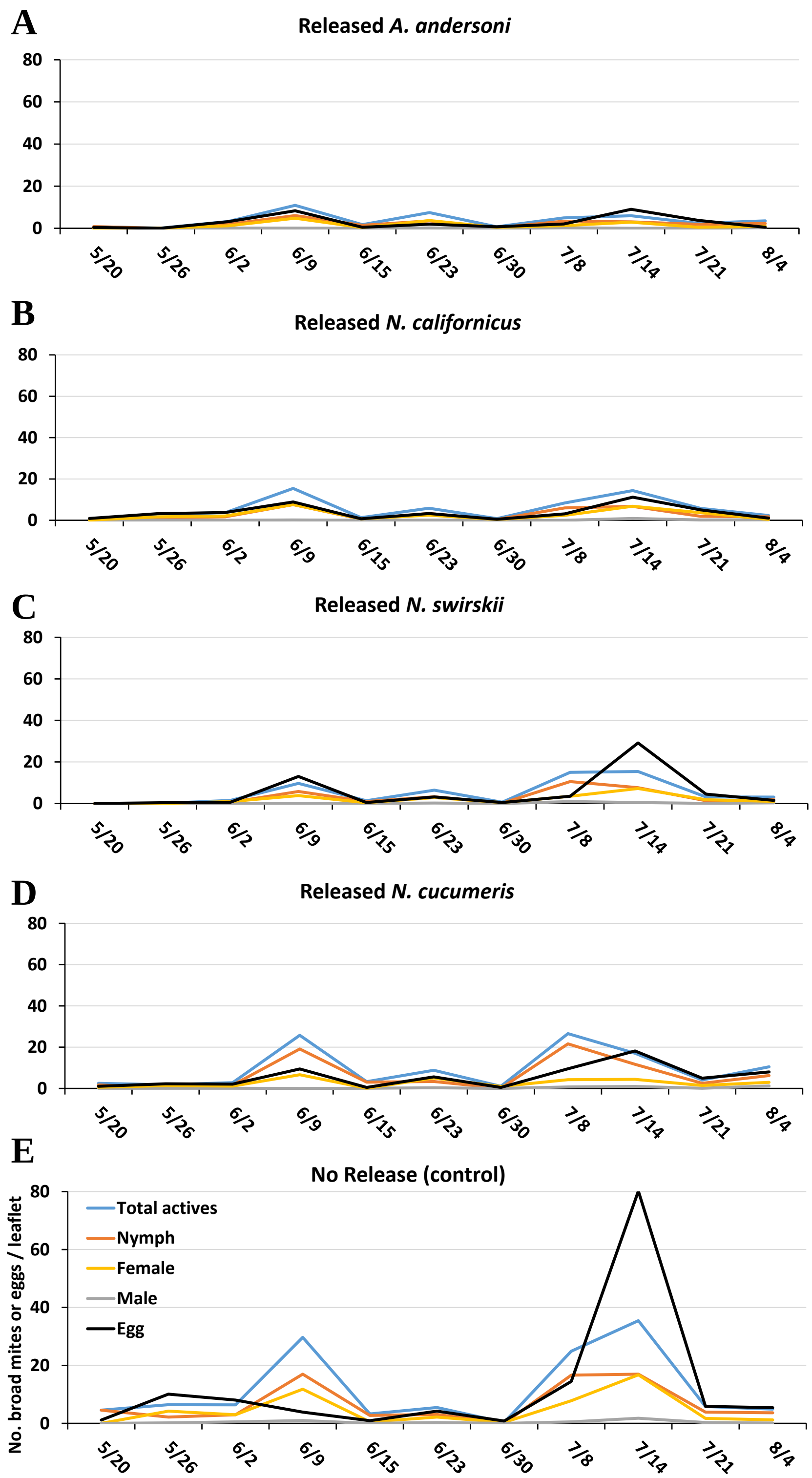

Figure 7. Mean (N = 3) numbers of broad mites per blackberry primocane terminal leaflet by growth stage after release on 20 May and 7 July of one of four predatory mite species: (A) *Amblyseius andersoni*; (B) *Neoseiulus californicus*; (C) *N. swirskii;* (D) *N. cucumeris*; versus (E) no release into 10 ft blackberry breeding selection plots at the Fruit Substation in Clarksville, AR (2016).

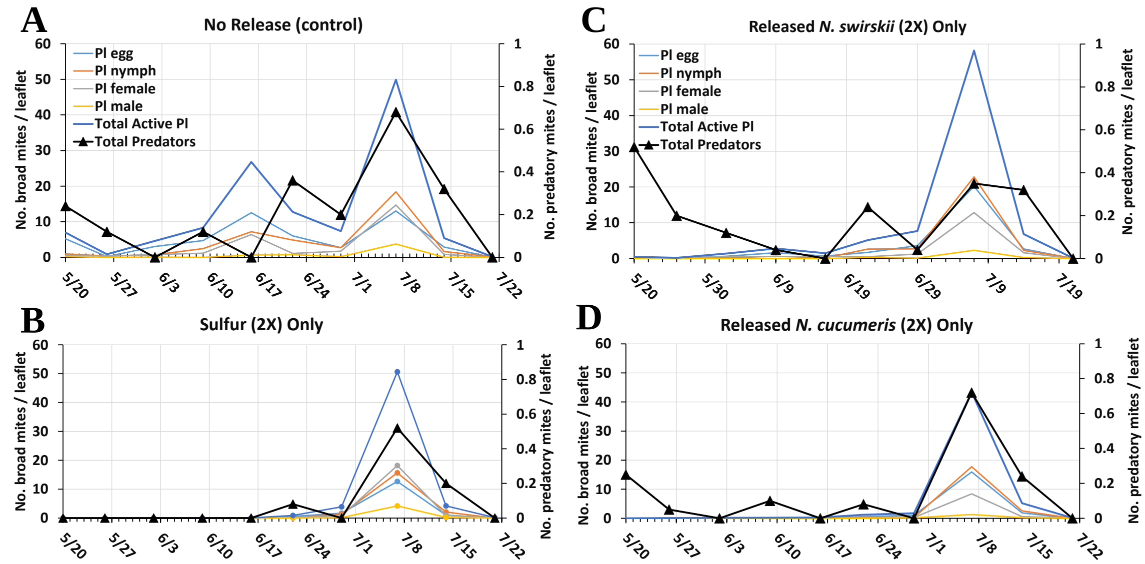

Figure 8. Mean (N = 5) numbers of broad mites by growth stage and numbers of predatory mites per blackberry primocane terminal leaflet in treated plots: (A) untreated; (B) Microthiol (sulfur) only applied on 7 and 20 May; or released either predatory mite species, (C) *Neoseiulus swirskii* or (D) *N. cucumeris*, in commercial Prime-Ark45® blackberry planting near Searcy, AR (2016).

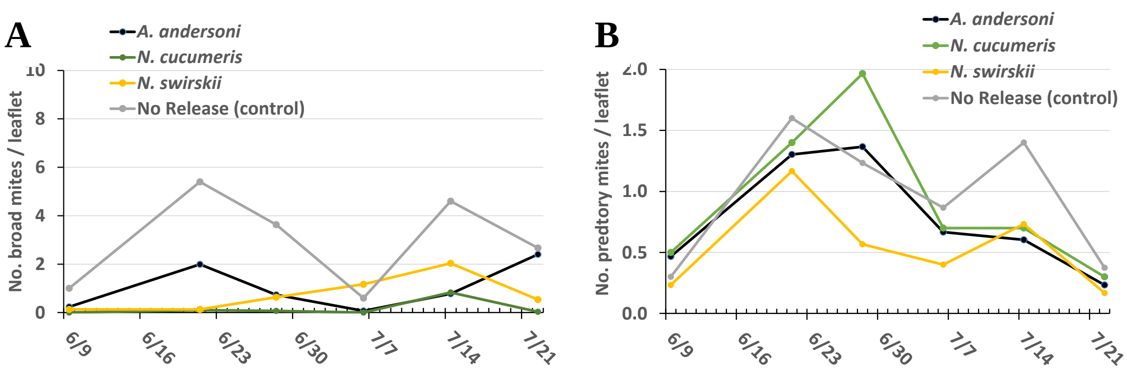

Figure 9. Mean (N = 3) numbers of (A) broad mites and (B) predatory mites per blackberry primocane leaflet in high tunnel in 10 ft plots with release of predatory mites (*Amblvseius andersoni* or *Neoseiulus cucumeris* or *N. swirskii*) at the AAREC-Farm in Fayetteville, AR (2016).

Impact Statement

The first foliar damage of the season alerts grower to begin inspecting newly expanded terminal leaves for broad mites. Broad mites can exceed the tentative action threshold of 5 broad mites per leaflet and begin to show foliar bronzing and cupping damage by mid-May in field plantings and mid-June or July in high tunnel plantings of primocane-fruiting blackberries. Once a few plants exceed 5 broad mite per leaflet, the infestation spreads quickly to the whole field planting but appears to be slower to spread in high tunnel plantings. In a laboratory bioassay, Agri-Mek, M-Pede, Microthiol and JMS Stylet Oil all caused > 90% broad mite mortality within 72 hrs. A field application of Agri-Mek on 15 July reduced and maintained broad mite counts near zero per leaf for over one month. In July 2016, FIFRA approved a Section 2(ee) recommendation to use Agri-Mek® SC in AR, FL, IL, IN, NC, PA, and SC for control of broad mites in caneberry. Field applications of Microthiol (sulfur) on 7 and 20 May or releases on 20 May of either of two predatory mite species (*Amblyseius andersoni* or *Neoseiulus californicus*) all delayed buildup of broad mites until late-June. Information on broad mite biology, scouting and the recommended miticide (Agri-Mek) was added to 2017 state and regional pest management spray guides. Several newsletters have been distributed to growers in Arkansas and Pennsylvania informing growers of how to identify broad mites and the damage caused to blackberries:
http://comp.uark.edu/~dtjohnso/AR_News_25_Apr_2016.pdf;
http://comp.uark.edu/~dtjohnso/AR_News_Special_Broad_Mite_14July_2016.pdf;
http://extension.psu.edu/plants/vegetable-fruit/news/2016/broad-mites-in-blackberries-a-2016-update.

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