Broad mite biology and management on blackberry (Progress Report)

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Objectives: 1) To describe the seasonal changes in density of broad mites on blackberry terminals; 2) To determine efficacy of several miticides and submit data to respective Chemical Companies to request EPA supplemental labels that include broad mite on blackberry (collaborate with The IR-4 Project); and 3) To optimize control of broad mite using a combination of cultural (spring mowing and tipping of primocanes) and timing of miticide applications to minimize number of applications per season.

Justification:

The objective for this study is to develop a science-based broad mite, *Polyphagotarsonemus latus* (Banks), management recommendation for blackberries.

In 2014, broad mites first appeared in and caused damage and reduced yields in commercial blackberry plantings in Arkansas, North and South Carolina (coolest summer on record). As a result, we had multiple requests for science-based broad mite management recommendations from small fruit growers. These recommendations for small fruit crops were non-existent since no miticide product has an EPA label for blackberry and broad mites. The expanding caneberry industry in low chill growing areas, like California and Utah, is also being confronted by broad mite pressure for which there are no effective tools (http://wrir4.ucdavis.edu/pst/details/11263.htm).

Previously, broad mite had not been reported on blackberry in the southeastern U.S. In September, 2007, the first *Rubus* species, primocane-fruiting (PF) blackberry cultivar 'APF-46', was reported attacked and damaged by broad mite in Johnson Co., AR. This mite caused reduced yields on blackberry in field and high tunnels conditions at the in Fayetteville, AR (Vincent 2008; Vincent et al. 2010). Within a month the damage appeared in most field plots of PF blackberries. It was not until fall 2014 that high broad mite populations were significantly reducing yields in the largest commercial PF blackberry field in White Co., AR. The grower at this location has an estimated loss of 15,000 to 20,000 dollars in revenue from reduced yield and fruit quality from damage caused by this pest. At the same time, it was noted that many blackberry plot selections at the in Johnson Co. were infested with broad mites and damaged. In September, this mite was also found causing terminal death of blueberries in Johnson Co. and table grapes in Washington Co. (Fig. 1) (http://comp.uark.edu/~dtjohnso/AR_News_5_Sep_2014.pdf).

The broad mite is distributed world-wide in tropical and subtropical areas in Australia, Asia, Africa, Europe, North America, South America, and the Pacific Islands. Broad mite has a large host range (55 dicotyledonous species) that includes: food crops like greenhouse grown peppers (Fan and Petitt 1994), melons, citrus (Gerson, 1991), and grapes (Ferreira et al., 2006); and many ornamentals, African violet, ageratum, azalea, begonia, chrysanthemums, cyclamen, dahlia, gerbera, gloxinia, ivy, jasmine, impatiens, lantana, marigold, pittosporum, snapdragon, verbena and zinnia. Adverse effects of the broad mite are usually observed on citrus in the fall (Gerson, 1991). A survey of pre-plant seedlings of greenhouse grown peppers showed that nurseries were a source of infestation for the broad mite (Weintraub et al. 2003).

Symptomatic of damage caused by broad mites are terminals with stiff, curled leaves with cupped margins, reduced leaf size and aborted flower buds (Gerson, 1991) on pepper (Coss-Romero and Peña, 1998), cucumber (Grinberg et al., 2005) and blackberry (Fig. 1). Late vegetative and early flowering stages of pepper were most susceptible to damage since these growth stages favored broad mite reproduction more than other stages (Coss-Romero and Peña, 1998). The same appears to be true for blackberry since broad mite damage of terminals appeared in Johnson Co. on blackberry floricanes in July and primocanes when flower began in September (Fig. 1). It is hypothesized that the best time to apply a miticide against broad mites will be before first berries begin to ripen on floricanes and primocanes.

The broad mite lays oblong, white eggs with distinctive pattern of white projections (Gerson, 1991) (Fig. 2). Adult mites are 0.2 mm long, females are translucent and colorless and males pale brown each with four pairs of legs. Broad mites disperse by wind, infested plant structures, by contact between the plant foliage (Hugon 1983), and via aphids and whiteflies (Fan and Petitt 1998 Palevsky et al. 2001). Ferreira et al. (2006) estimated mean generation time for broad mite development as 25.6, 10.8 and 8.2 days, respectively, at temperatures of 18, 25 and 32°C. In temperatures of 18, 25 and 32°C each female deposited, respectively, 16.5, 44.3 and 13.3 eggs. Egg, larva, pupa and egg-adult period had thermal constant of 28.5, 14.6, 8.3 and 62.7 degree days respectively.

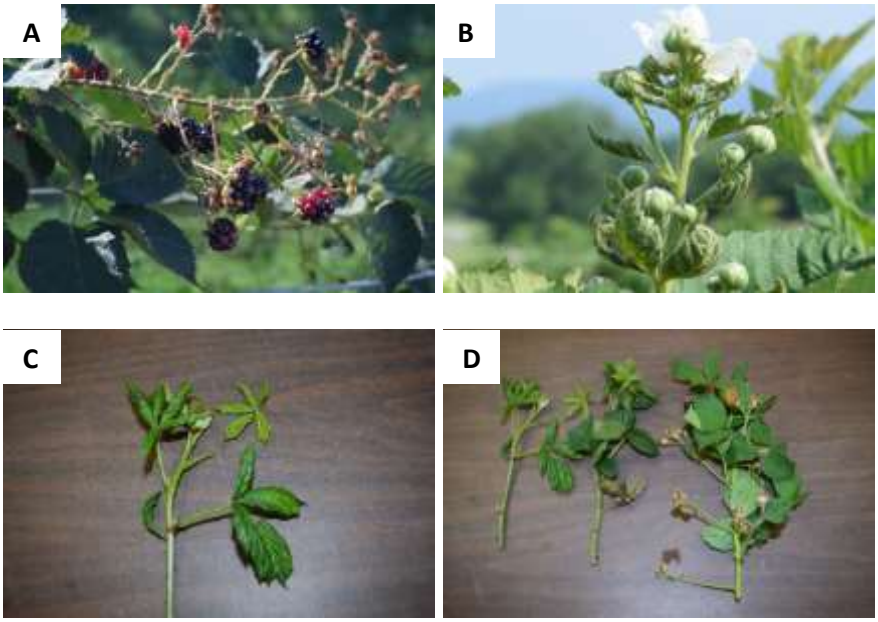

Figure 1. A) Broad mite damaged blackberry fruit clusters and (B) upward curled terminal leaves on floricanes on 23 July, (C) downward curled terminal leaves of primocanes on 24

September, and (D) side-by-side comparison of broad mite damaged (left) and healthy terminal leaves and fruit (on right) in 24 September in Johnson Co., AR (2014) (Photos: Donn Johnson)

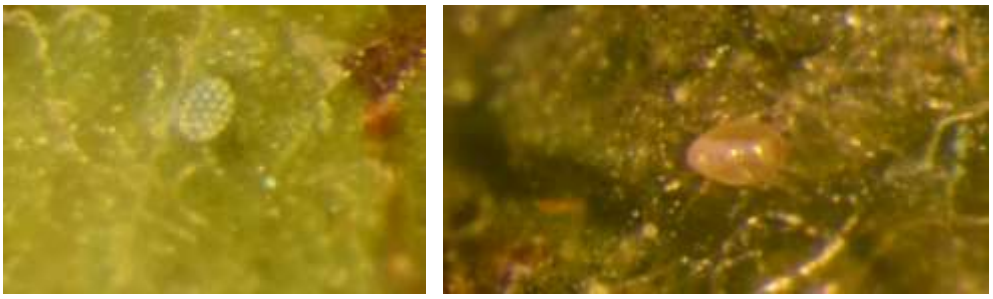

Figure 2. Broad mite egg and adult on underside of blackberry leaf (Photos: Donn Johnson)

Several miticides have been evaluated for efficacy against broad mite on crops other than blackberries. A citrus leaf dip bioassay demonstrated that Oberon, Magister (proposed for berries by Gowan Co.) and Agri-Mek (Avid) were most toxic to broad mites with LC_{50} values of 0.05, 0.06 and 0.07 ppm, respectively (Anjitha et al. 2014). Palmer and Vea (2012) reviewed miticide efficacy reports to The IR-4 Project including that by Gilrein in 2010 who noted excellent broad mite control with no injury or growth reduction achieved using Avid. It was noted that Avid, Proclaim (Emamectin Benzoate), and Pylon (Chlorfenaphyr) provided the greatest level of initial and residual control of broad mites. The last two products are registered only on row crops so will not be tested on blackberry. The ESA Arthropod Management Tests had 11 miticide efficacy studies reported that are summarized as follows: Agri-Mek, Movento, or Tolfenpyrad significantly reduced numbers of broad mites on pepper (Stansly and Kostyk 2013) as did Oberon or Movento (Schuster 2005; Stansly and Kostyk 2012). For 2014, The Western region IR-4 Project gave Tolfenpyrad an 'A' priority for testing on caneberry against broad mites. However, there were concerns for using Tolfenpyrad when pollinators are present so this product will be restricted for broad mite control pre-bloom when canes are vegetative or when establishing plants (http://wrir4.ucdavis.edu/pst/details/11263.htm). JMS Stylet Oil will not be tested since most treatments may occur during periods when maximum daily temperatures exceed 32°C which could cause phytotoxicity.

No miticide efficacy/timing studies against broad mites on blackberry have been reported to date. The data gathered from this research project will be used to add blackberry and broad mite to EPA supplemental labels for several miticides: Agri-Mek, Magister, Movento, Oberon, Tolfenpyrad, Zeal. Miticide efficacy data will be submitted for Section 24(c) registrations against broad mite (additional use) on blackberry (new end use) for these miticides:

- Agri-Mek (abamectin) - is not labeled on blackberry, but Agri-Mek lists hatching immature broad mite on citrus and on fruiting peppers, eggplant, tomato
- Magister (fenazaquin) – for motile stages; apply as mites start to build in numbers
- Movento (spirotetramat) – against motiles
- Oberon (spiromesifen) - is not labeled on blackberry, is registered for broad mite immatures on fruiting vegetables (peppers, eggplant, and tomato)
- Tolfenpyrad (tolfenpyrad) - (http://wrir4.ucdavis.edu/pst/details/11263.htm).
- Zeal (extoxazole) - has a Section 2(ee) for caneberries, strawberry, small fruit vine, but does not list broad mite; has a Section 2(ee) for pepper and eggplant that lists broad mite (larvicidal mite growth regulator). Zeal works on contact and has translaminar movement.

The PF blackberries that bloom and fruit in fall often do not set fruit if late summer temperatures are too hot. Research has demonstrated that mowing primocanes and tipping in the spring can delay fruiting of PF blackberries to cooler fall periods (Rom and Garcia 2008). This spring pruning and tipping may also delay broad mite reinfestation of blackberry primocanes and help growers to delay miticide applications which could equate to fewer miticide applications per season.

The following methods will be used to gather biological, toxicological and cultural data about broad mites on blackberries in order to develop a pest management recommendation for broad mite on blackberries.

Methodologies:

Seasonal biology: Johnson will conduct a seasonal biology study of broad mite appearance and record densities per leaf at the Johnson Co. (180 mi. round trip) and White Co. (240 mi round trip). Twelve biweekly trips to Johnson and White Co. will start in late-April as primocanes emerge. Biweekly samples of ten terminal leaves from each of 10 blackberry plants in each of five plots per site (plots flagged) will be collected, bagged, labeled, mite brushed and count broad mite eggs and motiles per leaf using a stereomicroscope.

Miticide efficacy: Johnson will determine efficacy of several miticides using a randomized complete block design of three rows (replicates) each with all treatment plots of five plants each. Buffers will be five plants or 10 ft between plots and one row between treated rows. At the first sign of broad mite curled leaves with 1 to 5 broad mites per leaf (see objective 1), five plant plots will be flagged, leaves sampled and plots treated with conventional products: Agri-Mek, Magister, Movento, Oberon, Tolfenpyrad, and Zeal; and OMRI products: M-Pede (potassium salts of fatty acids; all stages), and SucraShield (sucrose octanoate ester; all stages). Each compound will be reapplied two week later against hatched mites, except for Zeal that is restricted to one application per season. Each treatment will be applied at recommended rates with a Stihl gas powered air blast sprayer delivering 2.5 ml/min. to both sides of plots. Eggs and motiles will be as described in Objective 1 at 0, 7, 14, 21 and 28 days after treatment. Two trips are expected to require an overnight when sprays are applied.

Optimize control: Garcia will see if mowing and tipping primocanes in spring will delay primocane flowering and fruiting of 'Prime Ark 45' blackberry to the cooler fall period in Arkansas. A commercial 'Prime Ark-45' blackberry planting in near White Co. will have all floricanes mowed down and removed in November 2014 to reduce overwintering broad mite numbers. These plants will have emerging primocanes which will be mowed and tipped down in late-April, early-May or late-May. Harvest data will be collected in fall from each mowed plot. In these same plots, Johnson will compare the effects of each date of mowing date on biweekly numbers of broad mites per terminal leaf from early-June to last harvest (counts made and analyzed as in objective 1). One trip is expected to require an overnight when plants are either tipped or mowed.

Statistical Analysis: All replicated data will be analyzed with ANOVA and means separated by Tukey's, $P = 0.05$.

Results:

Cultivar Susceptibility: It was unknown if any blackberry breeding selections or cultivars had resistance to broad mites. An opportunity arose to add another objective to this project. I asked Dr. John Clark (University of Arkansas fruit breeder): *What is the potential for genetic differences for resistance to broad mites among the blackberries in the breeding program at the University of Arkansas Fruit Station in Clarksville, AR?* On 13 Sept 2015, John answered as follows, "*I went through 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.*"

Seasonal biology: Biweekly records were made of the seasonal changes in mean numbers of broad mites and predator mites (*Neoseuilus fallacis*) per blackberry leaflet and appearance of the first terminal leaf cupping damage on blackberry plants. In Providence, AR, the 1 acre commercial planting of primocane fruiting Prime-Ark45® blackberries had 25 ft long plots each with five plants set 4 ft apart between trellis posts and 14 ft between rows. The grower planned to produce only primocane fruit in late summer by pruning floricanes to the ground in April. By 17 April, all floricanes in the east six rows where the efficacy study was conducted (see ***Miticide efficacy***) were pruned off at the ground, the middle four rows had only been pruned to knee high and the remaining west rows had not been pruned. On 17 April, the unpruned rows had flower buds with signs of strawberry clipper severed stems. By 1 May, all rows had been pruned to the ground and each row had primocanes emerged to knee high. From 15 July on, this and an adjacent 1 acre primocane planting was cooled by a shade cloth held 8 ft overhead by horizontal wires. There was no fruit harvest in these plantings due to severe broad mite damage to fruiting terminals from mid-June through fall (**Fig. 3**).

The seasonal changes in broad mite numbers was determined from 31 March 2015 on, by biweekly collections per blackberry plot of five to ten leaflets from the 2nd expanded leaflet from the terminal tip from 12 plots. Low numbers of broad mite eggs and motiles were detected on 17 April which increased above 5 broad mites or eggs per leaflet between 2 and 18 June and maintained density greater than 25 broad mites and eggs per leaflet into August (**Fig. 3**). By 18 June, we found the first male broad mites and noticed the first cupped foliar damage in the planting. From mid-April into August, there were less than 0.2 native predator mites (*N. fallacis*) per blackberry terminal leaflet detected. *N. fallacis* may not be adapted to feed effectively on broad mites. It had a low density per leaflet and we saw no reduction (biological control) in numbers of broad mites. The predator: prey ratio remained less than 0.008. Typically need > 0.1 ratio for biological control to occur.

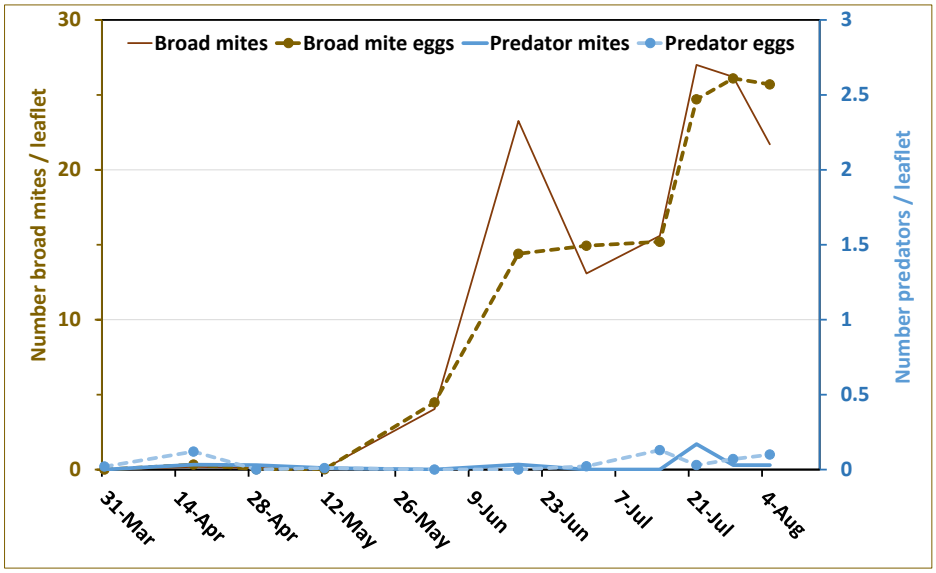

Figure 3. Seasonal changes in numbers of actives and eggs of both broad mites and predator mites per leaflet (0.24 cm^2 area) from the 2nd expanded leaf from terminal tip of commercial PrimeArk®45 primocane blackberry plant in Providence, AR (2015)

Open field plantings of several blackberry cultivars and breeding selections at the University of Arkansas Fruit Station in Clarksville, AR.

Three primocane fruiting blackberries (PrimeArk®45, PrimeArk® Traveler APF205) were growing in a high tunnel with insect exclusion netting over the 5 ft sides and 12 ft ends at the Arkansas Agricultural Research and Education Center in Fayetteville, AR.

Miticide efficacy: Several miticides were evaluated against broad mites in the PrimeArk®45 planting in Providence, AR. All floricanes had been cut off at the ground by 1 May. The primocanes that emerged had developed more than 5 broad mites and eggs per leaflet by 2 June (**Fig. 3**). On 15 July (0 DAT), a gas powered Stihl airblast sprayer (capacity of 2.6 gal = 10 liters) applied each miticide spray treatment in randomized complete block design (3 replicates, 25 ft plots each with five blackberry plants) (**Table 1**). Ambient temperature increased from 77°F at 7am to 93°F that afternoon which was too hot to apply JMS Stylet Oil. JMS Stylet Oil application was delayed until 22 July at 80°F since it reached only 90°F that afternoon. On 15, 22, 29 July, 8, 19 August and 2 September 2015, one leaflet from the 2nd developed leaf from the tip was collected from each of five or ten primocane terminals per treatment plot. Treatment mean numbers of broad mites were similar at 0 DAT (Table 2). Numbers of all broad mite stages (actives, males, females, nymphs and eggs) were significantly reduced one week after application of Agri-Mek, Magister or Apta (**Table 3**). Zeal provided similar broad mite control as Apta and M-Pede (potassium salt of fatty acids) and all had better control than the untreated check. However, there were no treatment difference after 7 DAT (**Tables 4-5**). Bayer CropScience requested that Oberon and Movento not be evaluated in this study.

Table 1. Miticide formulations and rates applied on either 15 or 22 July (only JMS Stylet Oil) in a Prime-Ark®45 blackberry planting in Providence, AR (2015).

Formulation	Active ingredient	Rate/100 gal/A	Rate/ 2.6 gal/3 plots
Agri-Mek SC	Abamectin	3.5 fl oz	2.7 ml
Apta	Tolfenpyrad	27 fl oz	24 ml
Magister	Fenazaquin	24 fl oz	18 ml
Zeal	Etoxazole	3 oz	2.21 gm
JMS Stylet Oil	White mineral oil	1%	98 ml
M-Pede	Potassium salts of fatty acids	1%	97.8 ml
Untreated check	Water		2.6 gal.

Table 2. At 0 days after treatment (DAT), miticide treatment mean numbers of broad mites by stages per leaflet area (2.4 cm^2 area) from the 2nd expanded primocane leaflet from terminal tip of a Prime-Ark®45 blackberry in Providence, AR (15 July 2015)

Treatment/ Formulation	Rate amt/acre	Mean numbers of broad mites/leaflet at 0 DAT				
		All actives	Males	Females	Nymphs	Eggs
Agri-Mek	3.5 fl oz	11.5a	0.1a	1.9a	9.5a	8.9a
Magister	24 fl oz	13.6a	0.5a	5.1a	8.0a	7.7a
Apta	27 fl oz	15.4a	0.7a	5.6a	9.1a	9.7a
Zeal	3 oz	11.9a	0.5a	3.9a	7.5a	9.4a
M-Pede	1%	10.7a	0.1a	5.1a	5.5a	9.8a
JMS Stylet Oil (7/22)	1%	17.8a	0.7a	4.7a	12.3a	11.7a
Check	water	15.6a	0.5a	5.9a	9.2a	15.2a

Means within column followed by same letter are not statistically different (Tukey; $P > 0.05$)

Table 3. At 7 days after treatment (DAT), miticide treatment mean numbers of broad mites by stages per leaflet area (2.4 cm^2 area) collected from the 2nd expanded primocane leaflet from terminal tip of a Prime-Ark®45 blackberry in Providence, AR (22 July 2015)

Treatment/ Formulation	Rate amt/acre	Mean numbers broad mites/leaflet at 7 DAT				
		All actives	Males	Females	Nymphs	Eggs
Agri-Mek SC	3.5 fl oz	0.5d	0.0b	0.1b	0.4c	0.8b
Magister	24 fl oz	0.9d	0.0b	0.4b	0.5c	0.6b
Apta	27 fl oz	1.5cd	0.1b	0.2b	1.2c	1.0b
Zeal	3 oz	12.2bc	0.7ab	5.1a	6.4bc	16.8a
M-Pede	1%	15.6b	0.5ab	5.2a	9.8ab	21.2a
JMS Stylet Oil (7/22)	1%	18.3ab	0.6ab	5.9a	11.8ab	17.1a
Check	water	27.0a	1.9a	7.9a	17.2a	24.7a

Means within column followed by same letter are not statistically different (Tukey; $P > 0.05$)

Table 4. At 14 days after treatment (DAT), miticide treatment mean numbers of broad mites by stages per leaflet area (2.4 cm^2 area) from the 2nd expanded primocane blackberry leaflet from terminal tip of a Prime-Ark®45 blackberry in Providence, AR (29 July 2015)

Treatment/ Formulation	Rate amt/acre	Mean numbers broad mites/leaflet at 14 DAT				
		All actives	Males	Females	Nymphs	Eggs
Agri-Mek SC	3.5 fl oz	8.5	0.2	1.1	7.3	8.7
Magister	24 fl oz	0.9	0.1	3.2	3.4	9.2
Apta	27 fl oz	11.8	0.4	3.4	8.1	10.1
Zeal	3 oz	21.1	1.3	8.2	11.6	9.0
M-Pede	1%	17.8	0.3	5.4	12.1	18.5
JMS Stylet Oil (7/22)	1%	12.7	0.2	2.8	9.8	14.5
Check	water	26.2	0.6	7.6	18.0	25.7

Means within column followed by no letter are not statistically different (Tukey; $P > 0.05$)

Table 5. At 21 days after treatment (DAT), miticide treatment mean numbers of broad mites by stages per leaflet area (2.4 cm^2 area) from the 2nd expanded primocane blackberry leaflet from terminal tip in Providence, AR (5 August 2015)

Treatment/ Formulation	Rate amt/acre	Mean numbers broad mites/leaflet at 21 DAT				
		All actives	Males	Females	Nymphs	Eggs
Agri-Mek SC	3.5 fl oz	8.5	0.2	1.1	7.3	8.7
Magister	24 fl oz	0.9	0.1	3.2	3.4	9.2
Apta	27 fl oz	11.8	0.4	3.4	8.1	10.1
Zeal	3 oz	21.1	1.3	8.2	11.6	9.0
M-Pede	1%	17.8	0.3	5.4	12.1	18.5
JMS Stylet Oil (7/22)	1%	12.7	0.2	2.8	9.8	14.5
Check	water	26.2	0.6	7.6	18.0	25.7

Means within column followed by no letter are not statistically different (Tukey; $P > 0.05$)

On 26 June in Fayetteville, AR, we found broad mites causing leaf damage and death in plants of PrimeArk®45in plot S3, one of eight 25 ft plots of blackberries managed organically inside a 200 ft high tunnel. This tunnel had 1mm x 0.6mm mesh exclusion insect screen covering the 5ft sides and ends. This allowed us to test efficacy of JMS Stylet Oil and M-Pede against broad mites. Inside the tunnel was a row of eight, 25 ft plots of three blackberry selections. The plots from south to north were PrimeArk®45 in plots S1-S3, APF205 in north part of plots S3-N4-N3, and PrimeArk® Traveler in plots N2-N1. On 10 July, a 1% JMS Stylet Oil solution was applied to a 25 ft length of row of broad mite-infested PrimeArk®45 plants in the north part of plot S2 and south part of plot S3 and reapplied on 21 July to an expanding broad mite infestation with foliar damage apparent from plots S1-S3. These two 1% JMS Stylet Oil sprays reduced the per leaflet numbers of both broad mites actives (**Fig. 4**) and eggs (**Fig. 5**) between 17 to 28 July. On 11 August, a 2% M-Pede solution was applied to all plots which reduced per leaflet numbers of active mites in all plots except plots S3, N3 and N1 (**Fig. 4**) and reduced egg counts in all plots except S3 and N3 (**Fig. 5**). By early-August, broad mites had finally moved north in the row to

the PrimeArk® Traveler plants in lots N2 and N1. Dr. Curt Rom's personnel collected yield data twice weekly from both the high tunnel and the adjacent field plantings of these three blackberry cultivars. By 31 August, the high tunnel blackberries out yielded the open field planting by more than 2-fold. However, the broad mite infestation in the high tunnel that occurred from late-June through July mostly in PrimeArk®45 plants (plots S1-S3 in **Fig. 4-5**) caused significant loss of fruiting terminals which slowed down production of cumulative marketable fruit yield in August (reduced slope) and very little yield added in September (0 slope or horizontal line) compared to a continuous cumulative yield increase in the same blackberry cultivars grown in the open field free of broad mites (**Fig. 6**).

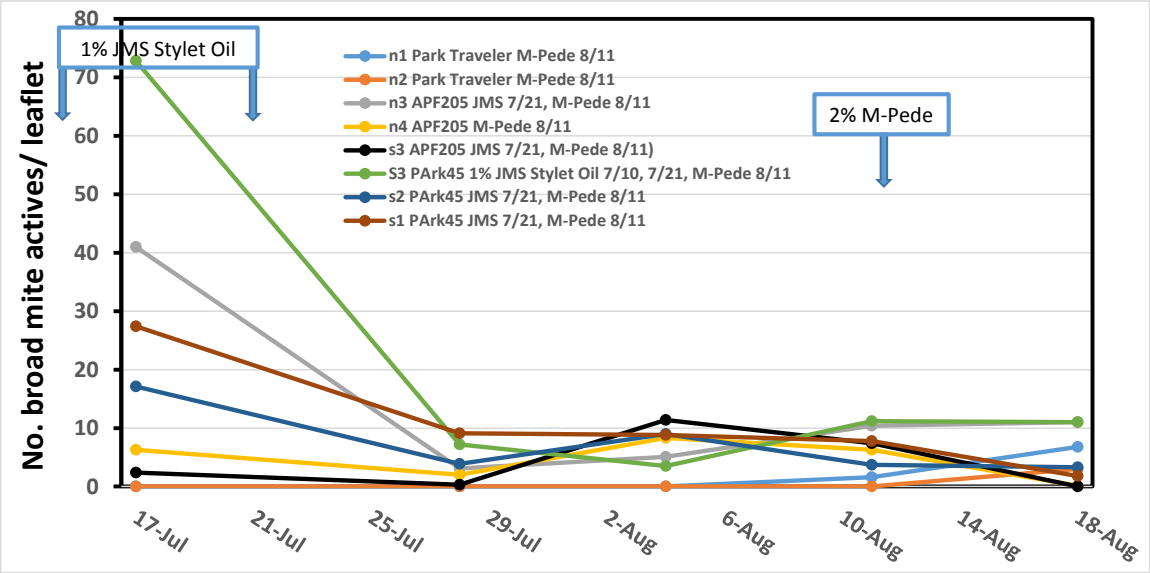

Figure 4. Mean numbers of broad mite actives per primocane leaflet (0.24 cm^2 area) on blackberries inside 200 ft long high tunnel managed organically in Fayetteville, AR (2015).

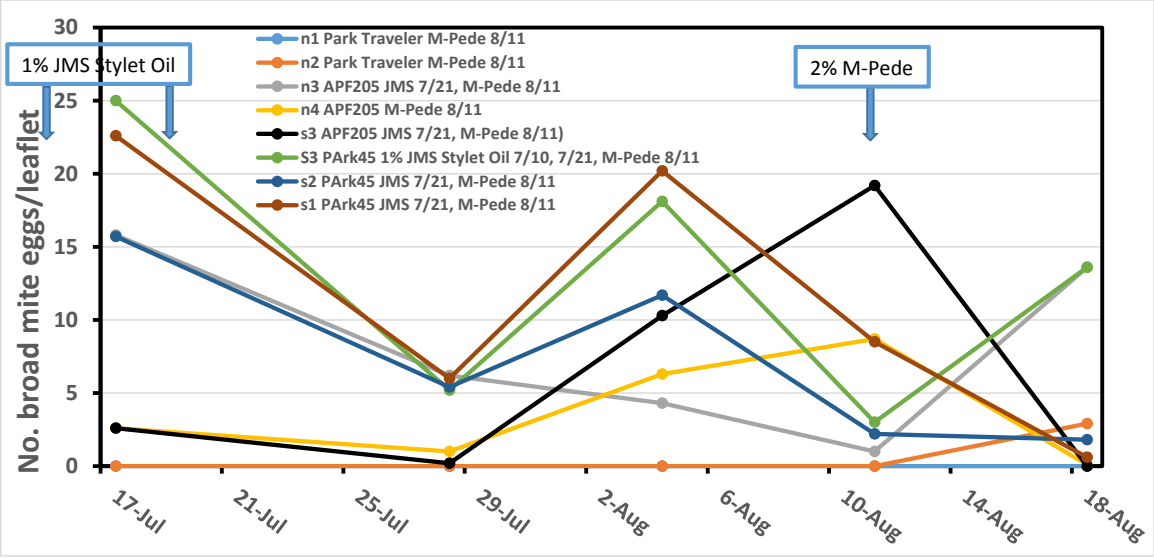

Figure 5. Mean numbers of broad mite eggs per primocane leaflet (0.24 cm^2 area) on blackberries inside 200 ft long high tunnel managed organically in Fayetteville, AR (2015).

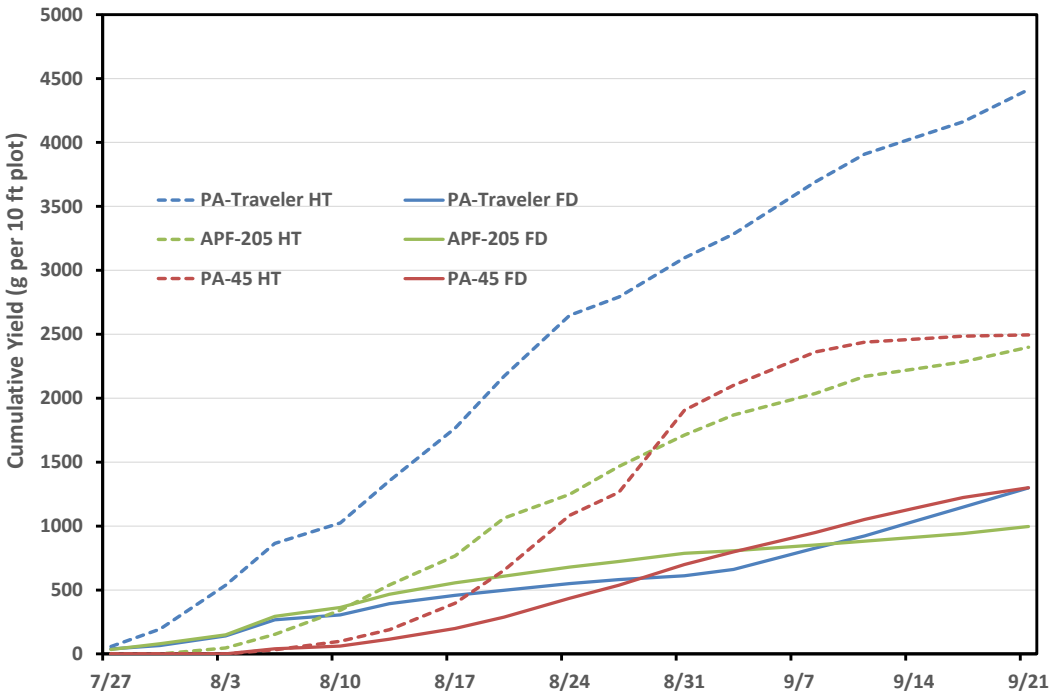

Figure 6. Cumulative blackberry fruit yields per 10 ft plot of three primocane fruiting blackberry cultivars (PrimeArk®45, APF205, and PrimeArk® Traveler) produced either inside the high tunnel (HT) with broad mites present causing damage or in an open field free of broad mites in Fayetteville, AR (2015).

Optimize control: In the PrimeArk®45 planting in Providence, AR, all floricanes had been pruned to the ground and removed from the planting by 12 May (**Fig. 7 A-D**). On 12 May, primocanes in three 25 ft plots were pruned back to the ground to see if it delayed primocane harvest and appearance of broad mites **(Fig. 7 E-F**). A delay in harvest could not be determined due to the lack of fruit produced in this planting due to broad mite damage to most fruiting terminals in June and July. Plots where floricanes were pruned to ground (removed) by 17 April had primocanes emerge and grow to knee high by 12 May. In comparison, after late pruning (removal) of primocanes to ground on 12 May, no primocanes were visible in these plots (**Fig. 7 E**). The late removal of primocanes on 12 May caused a lag in buildup of broad mites noted by lower numbers of broad mite adults and eggs per leaflet on 9 June compared to plots with floricanes removed on 17 April. From 16 to 30 June, all plots had similar counts of broad mite adults but had slightly lower numbers of eggs in the plots where primocanes were removed on 12 May. In July, the numbers of broad mite adults in primocane removed plots dropped below that seen in the floricane removed plots. By August, broad mite numbers were much greater in the plots where primocanes were removed on 12 May than plots where floricanes were removed on 17 April (**Fig. 8**).

Figure 7. Progression of spring pruning to ground of commercial planting of Prime-Ark45® in Providence, AR: A) unpruned overwintered floricanes on 31 March; B) east rows of floricanes pruned to ground by 17 April; C) floricanes in center rows pruned to knee high but not pruned in west rows on 17 April; D) all floricanes had been pruned to ground by 12 May; E) Elena Garcia just pruned three 25 ft plots of primocanes to the ground on 12 May to delay fruiting; and F) same plot with primocane growth on 2 June (2015).

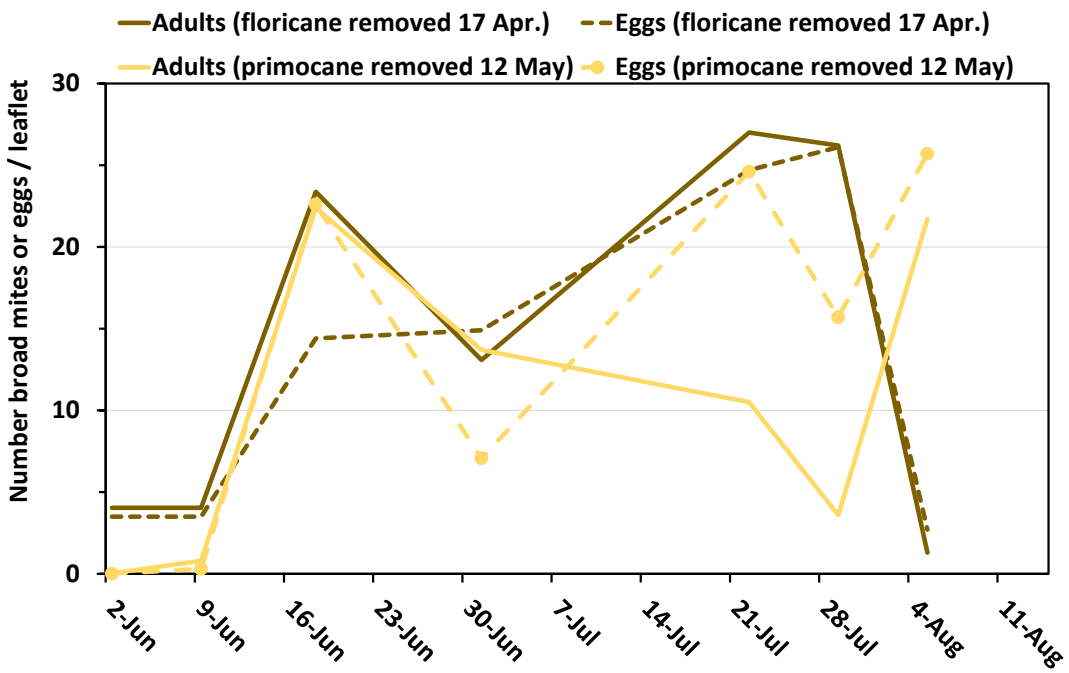

Figure 8. Mean number (N = 3) of broad mite adults (all actives) and eggs per primocane blackberry leaflet from PrimeArk®45 plots where floricanes were pruned (removed) to ground on 17 April (brown) or primocanes were pruned (removed) to ground on 12 May (light orange) in Providence, AR (2015).

Conclusions: The broad mite is a new pest that has been confirmed to be present on blackberries, has caused foliar and flower bud damage and reduced yields in field and high tunnel plantings of primocane fruiting blackberry cultivars in Arkansas as noted in this report. Low numbers of broad mite eggs and motiles were detected on primocanes of PrimeArk®45 blackberries by 17 April. The predator mite (*N. fallacis*) numbers remained too low (< 0.01 predator: prey ratio) to provide biological control of broad mites on these blackberries. Densities exceeded 5 broad mites or eggs per leaflet between 2 and 25 June which corresponded to first appearance of cupping and dying of expanding terminal leaves in both field and high tunnel blackberries. The density remained greater than 25 broad mites and eggs per leaflet from mid-June through July (**Fig. 3**). Numbers of all broad mite stages (actives, males, females, nymphs and eggs) were significantly reduced one week after application of Agri-Mek, Magister or Apta (**Table 3**). Zeal provided similar broad mite control as Apta and M-Pede (potassium salt of fatty acids) and all had better control than the untreated check (**Table 2**). Sprays provided no more than 1 week of reduced broad mite numbers when applied to blackberry plants that averaged more than 10 broad mites per leaflet reduced broad mite numbers per leaflet (**Tables 3-5**). In a high following organic practices, two applications of JMS Stylet Oil reduced numbers of broad mite actives and eggs as did one application of M-Pede applied in August (**Fig. 4 and 5**). It appears important to apply miticides between 1 to 5 broad mites per leaflet which is before the appearance of the males that may play a role in dispersal of females to other plants. Broad mite infestation in the high tunnel slowed down blackberry yield in August with little to no yield in September compared to continuous yield in the adjacent field planting that was broad mite free

(**Fig. 6**). The pruning to ground of primocanes on 12 May did not delay harvest but did cause some lower counts of active broad mites per leaflet (**Fig. 8**). We proposed in 2016 to continue to describe the seasonal biology of broad mites and damage on blackberry and to determine the most effective combination of miticide application and/or release of a predator mite species for more sustainable broad mite management in blackberry.

Impact Statement:
The broad mite is a new pest of blackberries in the United States. Since 2006, we have been asked and have confirmed the presence of broad mites and its damage to primocane blackberries in several states: California, Illinois, Indiana, New York, North Carolina, Pennsylvania, and South Carolina. Outreach to growers about identifying broad mites and the damage caused to blackberries has occurred in several states via pest alert newsletters (Johnson 2015, Demchak and Johnson 2015), a blog (Bolda 2015) and talk on broad mites at the XIth International *Rubus* and *Ribes* Symposium (Johnson et al. 2015). We are developing a broad mite monitoring method for blackberries. This involves randomly collecting 10 blackberry leaflets from primocane terminals at the position of 2nd expanded leaf. Each leaf is turned bottom side up to count the mites and eggs on the underside. Due to leaf curling, we forced the leaf to be flat by placing a ¼" mesh metal screen (½" x ¾" or 0.24 cm^2 area) over the leaf and used a stereomicroscope to count the number of broad mite actives and eggs along the midrib of the leaf. Using this monitoring method we noted that broad mite numbers began to build up on terminal blackberry leaves by late-May and damage was apparent by mid-June in Arkansas. It appears that a miticide should be applied or predator mites released before you detect terminal damage which appears to equate to between 1 to 5 broad mites per blackberry leaflet (0.24 cm^2 area). Efficacy tests found that Agri-Mek, Apta, Magister, Zeal, JMS Stylet Oil and M-Pede provided some broad mite control. Only Zeal and M-Pede are registered for use on blackberries but none are labeled against broad mites on blackberries. We will be investigating which predator mite species have the greatest potential to provide biological control of broad mites in the field and in high tunnel production systems.

Citation(s):
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