

## Occurrence and Damage of Broad Mites (*Polyphagotarsonemus latus* Banks) in Sweet Pepper (*Capsicum annuum* L.) in Samoa

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### ABSTRACT

Broad mites regularly infest sweet pepper crops in the tropics. A survey was carried out to assess its incidence in sweet pepper crops in Upolu, Samoa. The population density of broad mites was related to plant developmental stages with the highest number of broad mites per leaf recorded at the early fruiting stage; no broad mites were recovered from plants at the seedling and vegetative stages. In a separate experiment, 3 sweet pepper varieties were artificially infested with 2 gravid female mites per seedling. At 7 days after infestation, a significant difference was observed in the 3 varieties with Yellow having the highest number of broad mites per plant followed by Giant Bell and Yolo Wonder at 62.0, 37.0 and 19.7, respectively. At 10 days, there was a significant difference in the mean population of broad mites on the varieties namely, Yellow (59.1 mites/plant), Giant Bell (32.4/plant) and Yolo Wonder (24.3/plant). The highest population of broad mites was observed on plants that had damage index level of 3 which corresponds to slight curling in the top leaves. This damage index was more common in Giant Bell and Yolo Wonder while leaf necrosis and defoliation were common on Yellow. Typical damage injuries observed on seedlings included distorted cupped leaves with zigzag veins, elongated petioles, and bronzed leaves and stem that later became necrotic and died. Farmers can use a severity index scale to help them recognize the presence of broad mites in their farms so that timely management can be done.

Keywords: Broad mites, Occurrence, Sweet pepper varieties, Damage Index

### INTRODUCTION

Broad mite, *Polyphagotarsonemus latus* Banks (Acari: Tarsonomidae), is a minute polyphagous herbivore that attacks plants from numerous crop families. The mite causes severe crop damage and yield loss in various parts of the world including Africa, Asia, North, Central and South America, the Caribbean, Europe and the South Pacific (Cloyd 2010, Fasulo 2000, Gerson 1992, Jovicich et al 2016).

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It is present in Samoa and infests solanaceous crops such as tomatoes, eggplant, chili and sweet pepper (Jovicich et al 2016).

In Samoa, sweet pepper is considered a high-value cash crop, and it is among 12 crops with high economic potential (Sesega et al 2011). For example, the price of sweet pepper from commercial farms in Fiji ranged from US\$4.37-5.34/kg while in Samoa the price was from US\$3.47-5.34/kg (Jovicich et al 2016). Poor fruit quality, loss of production due to pests and diseases, rainfall and warm weather events affect the supply of fresh sweet pepper in the market. Growing sweet pepper under protective cultivation (eg, using structures such as high tunnels covered with polyethylene films) can help increase the local supply of pepper.

Plants grown under a tunnel structure covered with polyethylene film are protected from rain. The presence of some insect pests can be reduced if insect exclusion screens cover all side openings of the tunnel structure. Recent introductions of tunnel house to Samoa (most of which are not equipped with insect exclusion screens) demonstrated an increase in production as compared to outdoor production (Jovicich et al 2016). In the tropics, however, the warm and humid conditions under protective structures can also favour rapid build-up of pest population. Pepper crop evaluations between 2014 and 2015 using protected cropping in Fiji and Samoa identified broad mites as the most recurrent pest of sweet pepper (Jovicich et al 2016).

Broad mite can cause economic damage in many greenhouse crops including the solanaceous family. Broad mites mainly attack the new growth resulting in curling of leaves and necrosis of growing points which can lead to yield loss in crops. Due to its minute size (approximate body length is 0.2mm), infested seedlings carrying a few mites may appear undamaged until serious damage is shown on the apical leaves after transplanting (Jovicich et al 2006). In addition, farmers who are not familiar with the injuries caused by broad mites often confuse them for virus infection, nutrient deficiency or effect of herbicidal damage, hence wrong control measures are often employed (Coss-Romero & Peña 1998).

This paper presents the survey of broad mite infestation in sweet pepper farms in Upolu, Samoa. Likewise, since there is no rating scale for its damage, a severity index for broad mites was developed and used to assess the severity and damage caused by broad mites on three common sweet pepper varieties.

## **MATERIALS AND METHODS**

### *A. Field survey*

#### *Survey location*

A survey was carried out in August 2016 in six sweet pepper farms in Upolu, Samoa, namely, Poutasi, Lotofaga, Nu'u, Faleasi'u, Tanumalala and Aleisa, the only farms where sweet pepper was cultivated. Ten per cent of the plants were randomly selected in the farm. The plants on the farms were categorised into different development stages, namely seedling, vegetative, flowering (flowers start to open), early fruiting (immature fruits < 12cm diameter) and late fruiting stage (fruits > 12cm diameter). Two apical leaves (2<sup>nd</sup> and 3<sup>rd</sup> leaf from the shoot tip), approximately 5-6cm in length, were picked from the middle shoot of each plants,

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placed in vials containing 70% ethanol and brought back to the lab and observed under a stereo microscope. Counts were made on the number of broad mites in all life stages and were reported as number of mites per sampled leaf.

### B. *Susceptibility of three sweet pepper varieties to broad mites.*

#### *Culture and maintenance of mite colony*

A set of five sweet pepper plants from each sweet pepper variety used in this experiment were planted in polythene bags filled with a mixture of soil and commercial substrate (Yates potting mix) at a ratio of 2:1 and maintained in the laboratory at  $27 \pm 3^\circ\text{C}$  and 75-78% RH. Broad mite females were collected from Indian nettle (*Acalypha indica* L.), a common weed found in most fields in Samoa, and transferred onto potted sweet pepper plants that were kept in the laboratory in a net cage (50 x 50 x 50cm) to build up the mite population. New sweet pepper plants were provided for broad mites fortnightly.

#### *Damage assessment of mites*

Three sweet pepper varieties namely, Yolo Wonder (blocky fruit shape and red color when ripe), Yellow (blocky fruit shape that turns yellow upon ripening) and Giant Bell (blocky fruit shape that is glossy green and changes color to lush red upon maturity) were used for this experiment. These were the most common varieties planted by farmers in Samoa. The seeds were raised in planting trays (32 x 28 x 6cm) filled with soil mixed with commercial substrate (Yates potting mix) at a ratio of 2:1; 50 seedlings were sowed per tray per variety in the nursery under the shed house. Seedlings were watered daily. When the seedlings were at the 2-leaf stage, they were fertilized every two weeks using a commercial soluble source of NPK (25:5:8.8) (Yates thrive all-purpose fertilizer), at a rate of 1 tsp/4.5L water). Seedlings were hardened at 30 days after sowing.

At 38 days after sowing, the 3-4 leaf stage seedlings were artificially infested with broad mites. Two female broad mites as well as male carrying pharate female nymphs were collected using a fine brush and placed onto the leaf of each seedling. They were then transferred into the tunnel house and arranged in a completely randomized design, with three treatments, replicated three times. Water barriers were placed between each planting trays to prevent broad mite movement.

The seedlings were observed daily and scored for the presence of broad mites with pictures taken to document the progress of damage. An injury-severity scale was also developed to help recognize the different damage in seedlings that host broad mites and understand the nature of infestation on the plant.

Sampling was carried out at 7 and 10 days after inoculation to measure the susceptibility of the varieties to broad mite if they were infested before transplanting. Fifteen seedlings per variety were assessed for the severity of damage observed. The plants were then uprooted, placed in sealed plastics and taken into the lab the same day for mite count under a stereo microscope.

*Statistical analysis*

Differences in number of mites on the three cultivars were determined using Analysis of Variance (ANOVA). The association between the number of broad mites and the damage index was analyzed using Chi-Square analysis. IBM SPSS Statistics 20 was used to analyse the data at probability level of  $\alpha \leq 0.05$  for significance.

**RESULTS AND DISCUSSION**

*A. Field Survey*

*Abundance of broad mites in sweet pepper farms*

The broad mite population at the different locations varied according to the developmental stages of sweet pepper (Figure 1). The stages were seedling, vegetative, flowering (flowers start to open), early fruiting (immature fruits < 12cm diameter) and late fruiting stage (fruits > 12cm diameter).

No broad mites were recovered from the seedling and vegetative stages; however, findings by Jovicich et al (2016) showed that seedlings were the most vulnerable to broad mite damage. Therefore, no mites were recovered at this development stage probably because the farmers had applied control measures. The flowering stage had a mean of 50 eggs, 10 larvae, five nymphs and four adults while early fruiting stage had a mean of 92 eggs, 34 larvae, five nymphs and 18 adults and the late fruiting stage with the mean of 54 eggs, 24 larvae, 10 nymphs and 24 adults.

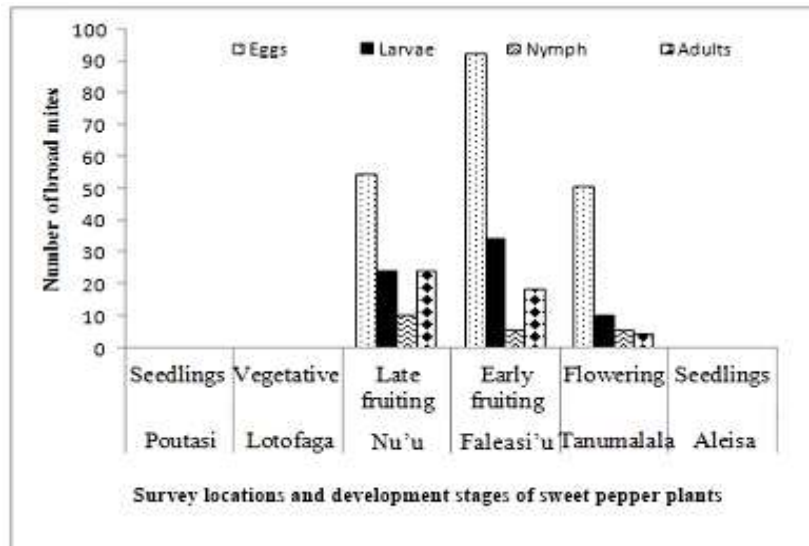


Figure 1. Broad mite population at different locations surveyed in Upolu, Samoa under different developmental stages of sweet pepper.

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### B. Sweet pepper varietal susceptibility trials

#### *Rating scale for broad mites damage*

Gerson (1992) stated that the variety of symptoms on different host plants reflected the specific plant's reaction to the broad mite feeding and supposed toxins injected into the leaves. For instance, Coss-Romero and Peña (1998) reported bronzing of apical leaves as damage observed on sweet pepper. However, it was not observed on jute plants as reported by Kumruzzaman et al (2013). Therefore, a damage rating scale for broad mite in sweet pepper was designed with slight modifications from that which were developed by Coss-Romero and Peña (1998) and Kamruzzaman et al (2013). Coss-Romero and Peña (1998) separated damage observed on pepper plants into 7 categories (Table 1). Kamruzzaman et al (2013) developed a similar rating scale for broad mite damage on jute plants under tunnel house conditions. Their rating scale had only 6 categories of damage (Table 2).

**Table 1. Damage categories for broad mites developed by Coss-Romero & Pena (1998)**

<b>Categories</b>	<b>Damage</b>
<b>0.5</b>	Apical leaves begin to curl causing the mid vein to become sinuous. Leaf colour changes from shiny green to opaque green.
<b>1</b>	The mesophyll cell under the leaf surface becomes sunken. The base of the leaf is lighter green in colour and apical leaves curl downwards.
<b>2</b>	Apical leaves become bronzed. Bronzing is found at the base of large leaves while small leaves are completely bronzed with necrotic tips and floral buds. The leaf area is reduced and damage is also observed in the secondary leaves.
<b>3</b>	Leaf petioles are thicker and elongated. Necrosis of floral buds.
<b>4</b>	The apical and lateral buds enlarged, but are deformed and fail to develop.
<b>5</b>	Apical leaves are necrotic and floral buds are aborted. Damage 1-4 is also observed in lateral leaves and floral buds.
<b>6</b>	Lignification of apical and lateral leaves. Enlargement of floral buds and necrosis of new leaves with deformed fruits.

Table 2. Damage index by Kamruzzaman et al (2013) for assessing damage of broad mites on jute plants












Damage Index	Description
0	Fresh and healthy leaves with no change in leaf colour.
1	Slight changes in colour of leaves
2	Curling of leaves
3	1 to 3 infested leaves dropped from the top
4	Premature defoliation of infested leaves but shoot is alive.
5	Top shoots all dead.

The severity index developed had a rating scale that was categorized into six levels at 2-point intervals with values from 1 to 9 (Table 3), a 9-point scale with word description. The international standard now used in the assessment of damage due to pests is the 9-point Hedonic Scale, which showed that longer scales tended to be more discriminating than shorter scales (Peryam 1998).

To have a clearer representation of the damage index in Table 3, colored pictures were taken of the different levels of damage observed on sweet pepper. Typical damages observed in the current study included slight change in leaf color, and slight sunken mesophyll cells that caused the leaf surface to be slightly rough. Petiole elongations, distorted leaves which are cupped, with zigzag veins, bronzed leaves and stem that later became necrotic and died were noted. Similar observations were made by Coss-Romero and Peña (1998), Jovicich et al (2004) and Rattanatip et al (2013) on chilli plants.

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Table 3. Damage index, description and illustration for broad mites in sweet pepper

Damage Index	Description	Illustration	Picture
0	No damage		
1	Leaf is slightly pale in colour with slight sunken mesophyll cells causing leaf surface to be slightly rough and thickened.		
3	Slight curling of apical leaves		
5	Elongation of leaf petioles and thickening of leaves.		
7	Curling of all apical leaves with mid vein lignified into zigzag pattern. Bronzing of leaves and stem, deformed buds along with the damage in 1, 3 and 5.		 
9	Necrotic apical buds and defoliation		

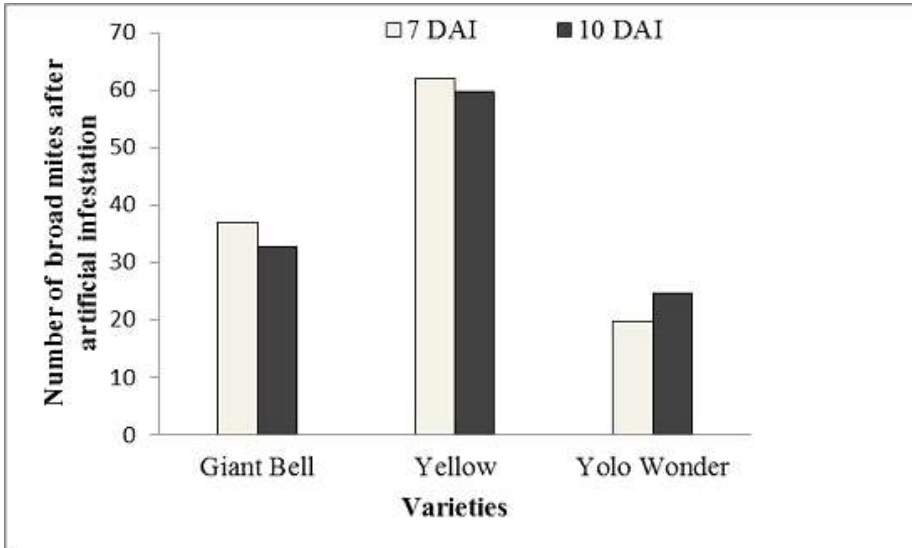
*Susceptibility of sweet pepper varieties to broad mites*

At seven days after inoculation, variety Yellow had the highest number of broad mites per plant followed by Giant Bell and Yolo Wonder ( $F_{2,6} = 244.14$ ,  $p = 0.00$ ). The number of broad mites on varieties Yellow and Giant Bell reduced 10 days after infestation while those in Yolo Wonder increased ( $F_{2,6} = 16.660$ ,  $p = 0.004$ ) (Table 4, Figure 2). The reduction in the number of broad mites on Giant Bell and Yellow was because of significant defoliation due to the damage of broad mites. This result may indicate that Yolo Wonder can withstand broad mite infestation better than the other two varieties.

**Table 4. Mean number of broad mites at 7 and 10 days after artificial infestation (DAI)**

Varieties	7 DAI	10 DAI
Giant Bell	37.0*	32.7
Yellow	62.0 *	59.7 *
Yolo Wonder	19.7*	24.7 *
F- Value	244.14	16.724
P-Value	0.000	0.00

\*The mean differences are significant at 0.05 level



**Figure 2. Number of broad mites of all life stages at 7 and 10 days after infestation**



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Using the Damage Index in Table 3, the three varieties were assessed for broad mite damage. The results of the current study showed that at DI 0, although no visible signs of damage were observed, broad mites were still found on the leaves especially on Yolo Wonder which showed more number of undamaged leaves than the other two varieties (Figure 3). It is important to note that although no visible damage may be observed on the plants, broad mites were still found on the plant. Jovicich et al (2016) in their evaluations of sweet pepper farms in Samoa and Fiji, had seen farmers physically removing infested seedlings that showed broad mite damage and the remaining healthy looking seedlings sold to farmers. These seedlings, however, were already infested and when they were planted, could widen the spread of the pest to other crops. In addition, once apical leaves showed damage, the mite population was already large enough to cause economic damage(2004).

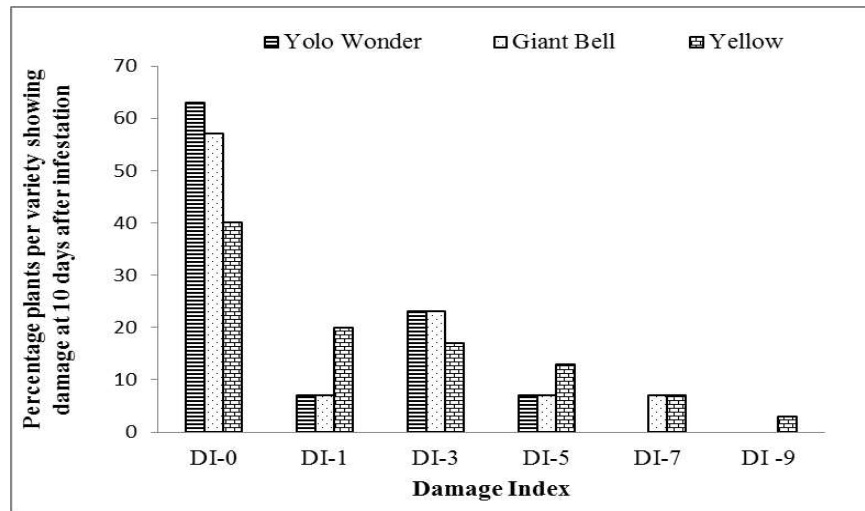


Figure 3. Percentage of plants per variety at each damage level

Although plants may exhibit the same damage on the leaves, the numbers of broad mites on the leaves were different for each variety (Figure 4). For instance, at DI of 3 and 5, Yellow had the most number of broad mites, followed by Giant Bell. This shows that damage wise, Yellow was the most damaged. Moreover, plants exhibiting damage injuries such as slight curling of apical leaves had the highest mite count. This would mean that control should be carried out at DI of 1 or DI of 0.

This information will be helpful to farmers in managing broad mites in their farms. DI of 7 and 9 had lesser number of broad mites. This could be because the tender tissues damaged by mites did not provide sufficient food for the population to stay on the plant and increase in number, due to leaf curling, making the leaves unsuitable for broad mites' development hence leading to their migration to other suitable hosts (Jovicich et al 2004, Rattanatip et al 2013). Therefore, if susceptibility is also linked to damage on plants, then again Yellow would still be the most susceptible due to it having a high number of damaged leaves during the observation followed by Giant Bell and Yolo Wonder.

There was a significant difference in the number of broad mites observed at each damage level (Figure 4). A higher number of broad mites was observed on plants with slight curling of apical leaves (DI 3) and leaf petiole elongation (DI 5) but lesser on plants that displayed curling of all apical leaves at 7 ( $F_{4,38} = 3.471, p = 0.016$ ) and 10 ( $F_{5,39} = 8.31, p = 0.00$ ) days after artificial infestation.

The number of broad mites decreased at 10 days after infestation while the damage increased. At DI of 9, the number of broad mites decreased.

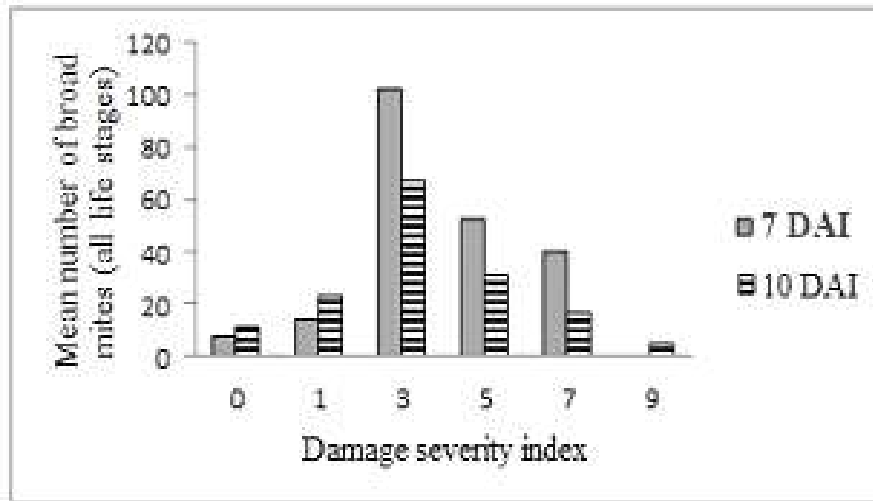


Figure 4. Mean number of broad mite count per damage index at 7 and 10 days after infestation.

#### *Broad mite life stages and habitat*

In all three sweet pepper cultivars, broad mites were observed to prefer the lower leaf surface of younger leaves. A similar observation was also made by (Coss-Romero & Peña 1998, Hafez et al 2010, Rodriguez et al 2011). The reason for the preference of lower leaf surface is because it is sheltered from high light intensity, low humidity and high temperature which are unsuitable for broad mite development (Coss-Romero & Peña 1998). The first and second apical leaves were observed to have maximum population while less number of mites was found on the lower leaves. This is because these are tender leaves which the mites prefer. This result was similar to those recorded by Rattanatip et al (2013) on chilli. However, an increase in population also resulted in broad mites of all life stages being found on upper leaf surface. Rodriguez et al (2011) and Coss-Romero and Pena (1988) mentioned that females were mostly found on the upper leaf surface as population increases but the findings of this study revealed that mites of all life stages were observed on the upper leaf, with more female adults than other stages. The females were easily dispersed with the aid of male carrying the pharate females in search for new food source.

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The preferred oviposition site on leaves was along the main veins but as the population increased, the oviposition site became random. Eggs were laid individually on the underside of the leaf and were oval-shaped, transparent with rows of white bumps (Figure 5A). Eggs hatched into six legged larvae (Figure 5B). Upon hatching the larva was white but later it became transparent. The nymph stage was observed to have pointed ends (Figure 5D) and was the immobile stage which emerged into an 8-legged adult. Nymphs were found mostly on older leaves while the pharate female nymphs (Figure 5D) were carried by the male onto new leaves. The males (Figure 5C) were observed to be smaller in size and spider looking, while the females (Figure 5E) were more gravid. The description of the life stages is in accordance with the findings of Coss-Romero and Peña,(1998), Gerson (1992) and Hafez et al(2010).

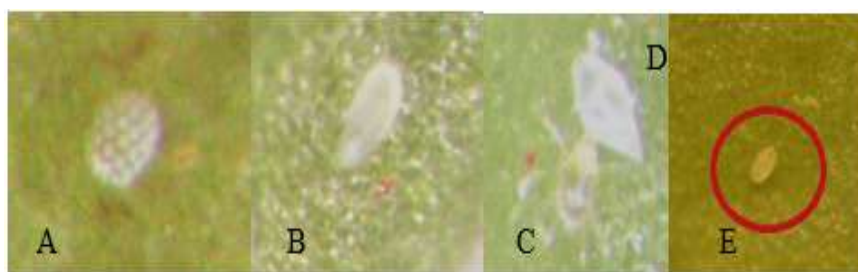


Figure 5. Broad mite life stages: A. eggs (188 x), B. larvae (100 x), C. male (91 x) carrying a female nymph D.(59 x) and E. female (51 x)

## CONCLUSIONS AND RECOMMENDATION

Broad mites are present in Samoa with higher population surveyed at early fruiting stages compared to later fruiting stages.

The three sweet pepper varieties used in this study were all susceptible to broad mites but they had varying degrees of susceptibility with variety Yolo Wonder proven to withstand broad mites better than the other two varieties. Therefore, Yolo Wonder can be used in an integrated program to manage of broad mites. The development of the damage index scale can help farmers recognize the presence broad mites on their farms for a timely control practice. Therefore, pamphlets on the damage scoring index of broad mite injury on sweet pepper should be provided to help farmers manage them.

## ACKNOWLEDGMENT

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