Population Dynamics of Mites on Monoculture and Polyculture Systems of Calina Papaya During Dry Season

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ABSTRACT
Papaya is an important commercial crop in various industrial sectors. Calina is the predominant variety liked by many communities and growers in Indonesia because of its superior traits and relatively stable price. In its cultivation, phytophagous mites infestations tremendously decrease the yield of papaya. Additionally, cropping system may affect the diversity, stability, and abundance of arthropod communities. This study aimed to evaluate the effects of planting system against mite population abundance. The research was conducted in Malang during 7 months of dry season (average of rainfall was 4.58 mm/month) in papaya monoculture and polyculture of papaya and sugarcane. Within each plantation, 25 papaya trees were randomly selected as samples. From each tree, 2 leaves were taken out based on the maturity i.e. young and mature leaves. Sampling was done at 1 week interval. Collected mites were counted, identified, and their population abundance were monitored. The results indicated that the most abundant of phytophagous mite population per leaf was *Tetranychus urticae* (74.75 ± 36.10), followed by *Panoncychus citri* (15.91 ± 7.45), and the lowest was *Brevipalpus phoenicis* (0.48 ± 0.55). While other was predatory mite *Neoseiulus* sp. (5.49 ± 4.21). The average of mite population abundance per leaf was greater on monoculture (26.01 ± 15.57) than polyculture system (15.42 ± 8.53), also it was higher on mature (26.48 ± 13.43) rather than on young leaves (14.95 ± 9.83). The study revealed that the polyculture system could greatly suppress the abundance of phytophagous mites, and likely promoted the biocontrol services by predatory mites.

Keywords: *arthropod communities, biocontrol services, cropping system, Tetranychus, Bravipalpus*

1. INTRODUCTION

Indonesian people often consume papaya fruit *Carica papaya* L. (Caricaceae) because of its high nutrition contents. Papaya has many benefits, and almost all parts of papaya plants can be used for various purposes, such as beer purifiers, meat tenderizers, industrial raw materials, and cosmetics [1-3]. The price of papaya fruit is relatively affordable and stable than other fruits, hence attracts farmers to plant it.

Indonesia has several popular papaya varieties, namely Papaya Calina and Thailand. The excellences of Calina are its medium size between 0.8-2 kg/fruit, oval-shaped, ripe fruit with bright red color, sweet taste with a sweetness level of 13 Brix, and thick flesh. Calina is a superior variety that has shorter planting periods, approximately seven months, than other varieties. Papaya planting widely spread in several regions in Indonesia, such as Bogor, Boyolali, Malang, Kediri, Banyuwangi, and Pontianak. However, the productivity of papaya in Indonesia tend to decrease during three years period of time. In 2012, 2013 and 2014 were 899 358, 871 257 and 830 491 tons, respectively [4]. One of the causes of papaya productivity decline is due to pest attack, one of which is mites. In general, species of mites that attack papaya are *Brevipalpus californicus* (Banks), and *B. phoenicis* (Geijskes) (Family Tenuipalpidae), *Tetranychus urticae* Koch, *T. cinnabarinus* (Boisduval), *T. kanzawai* Kishida, *Panonychus citri* (McGregor), and *Polyphagotarsonemus latus* (Banks) (Family Tetranychidae) [5-9].

Mites are small arthropods with length of 0.1-0.5 mm that makes it easy to move and adapts easily to the environment and avoids attacks from larger predators [10]. *Tetranychus* caused many losses in various crops in Indonesia. In general, these mites was controlled chemically with acaricide, but it can cause mite resistance within a few years. In addition, *Tetranychus* also attack various fruit-bearing crops such as citrus, avocados, and apples. Meanwhile, *T. cinnabarinus* attacks papaya on the underside of the leaf, causing wither and die. *T. cinnabarinus* is also found on cassava, nuts, and ornamental plants. It shows that this mite has a wide range of host plants [10]. The mite *P.*

citri is the most commonly mite found on papaya leaves in Lombok. Moreover, *P. citri* has spread widely across Indonesia's islands.

Integrated pest management (IPM) is expected to reduce the adverse effects of mites. IPM concept considers ecosystem stability and the sustainability of production [11, 12]. One component that composes the agricultural ecosystem is the cropping system. Control of pests and diseases employ a cropping system which affects the existence of arthropods [13]. Polyculture system can suppress the population of major plant pests. Polyculture system will be more efficient in suppressing pest attacks, because it can be a pest repellent from the main crop which affects the behavior and growth of insects on host plants [12, 14, 15]. In the other hand, monoculture system generally produce abundant harvests, but plants are more susceptible to pests or diseases [16].

Tetranychus spp. found attacks papaya in monoculture fields on Ciomas Region, Bogor. *Tetranychus* spp. attacks the underside leaves and leaf veins. Female adults are commonly found on Arum Bogor varieties. The mites also attacks papaya that are planted together with chilli and carrot on Megamendung Region, Bogor. In papaya polyculture system, all stages of *Tetranychus* spp. could be found, and unidentified mites are also found. The mite population of *Tetranychus* sp. in monoculture papaya plantation is higher than intercropping plantation. The application of pesticides by the farmers allegedly causes high proportion of the mite, even on 1 week old plant. It can be a detrimental effect to the predator population in the crop and resurgence occurrence of the mite.

Research on phytophagous mites and predatory mites and their abundance in Calina papaya varieties have not been conducted recently on monocultures and intercropping. East Java Province is the highest papaya production center in Indonesia. Malang is one of the most papaya producers in East Java [4]. The presence of mites on papaya plants is thought to be a secondary pest that is not considered yet, and the population is unknown. This research was expected to provide population data and species of mites that attack papaya plants in Malang. By knowing phytophagous mites and predatory mites as well as their populations, it is expected that they can be used to arrange mite control strategies. The purpose of this study was to examine the types of predatory mites and phytophagous mites and their abundance in Calina papaya variety in monoculture and polyculture system.

1.1. Materials and Methods

This research was conducted in Malang at Calina papaya plantation with monoculture and polyculture (intercropping) systems. On polyculture, papaya was intercropped with sugarcane. The characteristics of research area can be seen on Table 1.

Table 1 The characteristics of land research area

Papapaya plantation systems	Plantation wide (m^2)	Number of trees	Elevation (m asl)
Monoculture	5,000	250	368
Polyculture	5,000	220 (Papaya) 616 (Cane)	339

1.1.1. Determination of papaya plants samples

The plant samples in monoculture and polyculture were located in the middle of the plantation to get relatively homogeneous conditions. Papaya plant samples were determined by purposive sampling on monoculture plantation with 25 plants. As many as 25 plants papaya plant samples on intercropping papaya and sugarcane were selected by purposive sampling among sugarcane plants.

1.1.2. Papaya leaves sampling

Each papaya plant sample was determined by 2 papaya leaves, consisting of young and old (mature) leaf. Total leaves used as samples were 100 strands. The detemined leaf samples were located at 150 cm upper the soil surface. The determined papaya leaf samples were then collected from the papaya plant and cut into 5 parts using scissors. Papaya leaf samples then were put into a labelled clear plastic bag. The plastic bag was placed in a cooler box, then the sample leaves were transferred to a refrigerator at 5˚C in the Plant Pest Laboratory of the Faculty of Agriculture of Brawijaya University to maintain the freshness of the leaves before observing. Sampling conducted once a week for 24 weeks.

1.1.3. Calculation of mite population

Calculation of the mite population was done by cutting again the leaf samples adjusted to the size of the Petri dish. The cutted leaves were placed on a Petri dish, and then examined under microscope. The species of mites found in each cutted leaf were recorded and counted the abundance of populations of eggs, larvae, nymphs, and male and female adults.

1.1.4. Measurement of temperature, humidity, rainfall, and altitude

Temperature and humidity were measured by thermo hygrometer, when collecting samples. Rainfall data was obtained from the Meteorology, Climatology, and Geophysics Agency (Badan Meteorologi, Klimatologi dan Geofisika/ BMKG). Altitude of research site was measured using an altimeter. The average of temperature and relative humidity in both fields was 31.8 ºC and 62.12%, whereas the monthy average of rainfall was 4.58 mm/month.

1.1.5. Agronomy Treatment of Respective Land

Agronomic treatment or maintenance practices on each monoculture and intercropping papaya land obtained from interviewing the landowner farmers. The agronomy practices interviewed involved of the dosage used, type, and frequency of chemical fertilizers, manure, leaf fertilizer, and pesticides as well as conducting cultivation studies. It turned out, fertilization on monoculture field was more frequent, as well as with an additional spray of foliar fertilizer.

1.1.6. Data Analysis

Data on population abundance of phytophagous mites and predatory mites were tested by the T-test at a 5% error level.

1.2. Our Contribution

We found that several phytophagous mite species are inhabiting Calina papaya tree, and they severely damaged the crops leading to yield losses. The phytophagous mites abundance is greater on monoculture than the polyculture system. This results give an insight that the monoculture plantation is more vulnerable to mite infestation, therefore a proper counter measures should be established in the future.

1.3. Paper Structure

The rest of the paper is describing the major results obtained in this study into two section. Section 2.1 presents the species of mites found in Calina papaya plantation both in monoculture and polyculture systems, as well as their abundance. In section 2.2, we explain the population dynamics of each mite species during the seven months dry season period.

2. RESULTS AND DISCUSSION

2.1. Mite Species and Their Abundance

The species of mites present in each field were the same, i.e., three species of phytophagous mites and one species of predator mites, but different abundance (Table 2). Two phytophagous mite species were found, *T. urticae* and *P.citri* belong to Tetranychidae family, and one phytophagous mite species, *B. phoenicis* belong to Tenuipalpidae family. Predatory mite found was phytoseiid *Neoseiulus fallacis* (Garman). It is known that the phytophagous mite species found in this research are also considered to be major pest of papaya in other countries [6-8]. Similarly, Collier *et al*. [7] also observed that *Neoseiulus* was the most abundant and ubiquitous predatory mite species in papaya tree during all seasons.

Table 2 The average of phytophagous mites and predatory mites abundance per papaya plant

Species of mite	Plantation system	
	Monoculture (× ± SD)	Intercropping (× ± SD)
Phytophagous		
Tetranychus urticae	80.77 ± 48.43 a	44.09 ± 23.78 b
Panonychus citri	16.73 ± 8.39 a	15.09 ± 6,31 a
Brevipalpus phoenicis	0.75 ± 0.77 a	0.22 ± 0.34 a
Predatory		
Neoseiulus fallacis	6.35 ± 4.21 a	4.64 ± 3.71 b

Description: The averages followed by the same letters are not significantly difference based on T-test at 5% error level, x (average populastion, SD (standard deviations)

Table 2 showed that the mite population in monoculture was significantly higher than in intercropping. The availability of abundant feed in monoculture crops caused the higher mite populations. The presence of sugarcane on intercropping might become an inhibiting factor for the mites to reach the papaya plant. Mites could move to other plants or habitats through wind and find their host randomly. Due to the presence of sugarcane, the mites could not reach the host plant. Another reason was due to the optimal fertilization on monoculture plantation, hence the papaya plants were healthier than intercropping. This condition caused the mite population development was more suitable in monoculture [17, 18].

Tetranychus urticae mites was the most dominant species inhabiting the papaya leaves in both fields (Table 3). These polyphagous and cosmopolitan mites often became a problem in various plantations. Meanwhile, other mite populations were relatively low. Of these, *P. citri*, eventhough it is a polyphagous species, citrus and apple plants were the main host for *P. citri*. When comparing the total mite abundance, number of mites found in monoculture plantation was significantly greater (Table 4). Based on this study, it also found that the population of mites on old leaves was significantly higher than on young leaves (Table 5).

Table 3 The average of phytophagous mites and predatory mites abundance per leaf in both fields

Species of mite	(× ± SD)
Phytophagous	
T. urticae	74.75 ± 36.10
P. citri	15.01 ± 7.45
B. phoenicis	0.48 ± 0.55
Predatory	
N. fallacis	5.49 ± 4.21

Table 4 The average of total mites abundance per leaf

Plantation system	(× ± SD)
Monoculture	26.01 ± 15.57 a
Polyculture	15.42 ± 8.53 b

Description: The averages followed by the same letters are not significantly differencebased on T-test at 5% error level, x (average populastion, SD (standard deviations)

Table 5 The average of total mites abundance on young and mature papaya leaves

Plantation system	Leaf maturity	
	young (× ± SD)	mature (× ± SD)
Monoculture	19.17 ± 13.89 b	32.85 ± 17.25 a
Polyculture	10.74 ± 5.78 b	20.11 ± 11.29 a
Total	14.95 ± 9.83 b	26.48 ± 13.43 a

Description: The averages followed by the same letters are not significantly differencebased on T-test at 5% error level, x (average populastion, SD (standard deviations)

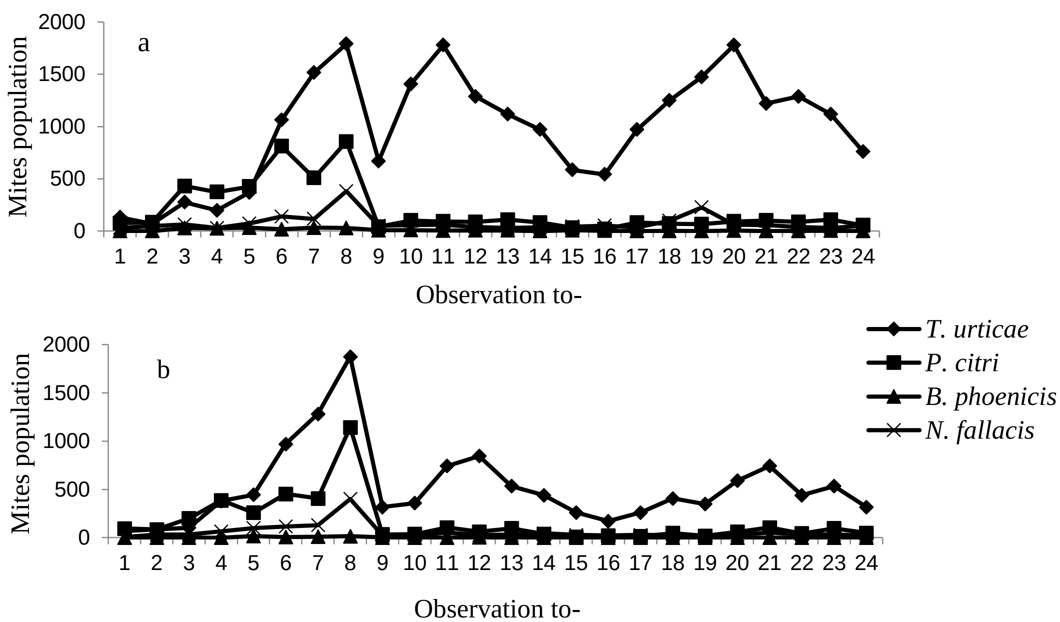

Figure 1 Fluctuations of population *T. urticae*, *P. citri*, *B. phoenicis*, and *N. fallacis* on papaya plantations (a) monoculture and (b) polyculture

2.1. Population Dynamics

The fluctuations in the population of phytophagous mites and predator mites in both fields have relatively similar patterns. The first population peak for all types of mites in both fields occurred in the third week of June. Then the population declined until the end of the observation, except *T. urticae* population, which increased again in monoculture land in July 3rd week and October 4th week with the same level of population. It seems that papaya is a suitable host for *T. urticae* so that the population is high, with three peaks of the population over 24 observations. In addition to the favorable weather conditions, which is no rain wih the appropriate temperature and humidity cause the population of *T. urticae* to fluctuate, and it repeatedly happens at a subsequent time.

Peak populations of *P. citri, B. phoenicis,* and *N. fallacis* mites occur only once in the 3rd week of June, then the population decline until the end of observation. Although it has a low population level, population fluctuations of *N. fallacis* predator mites follow the fluctuation of phytophagous mite populations. It shows that there is an adrift relationship between predator mites and prey phytophagous mites, namely the density of participation of predator mites that take the density of prey mites. The prey of phytophagous mites gives the predatory mite *N. fallacis* a breed. The predatory mite of the genus *Neoseiulus* classified as a type II predatory mite, and some species classified as type III. Type II predatory mites are selective predators of tetranychid mites (mostly related to species that produce solid species), namely the genus *Galendromus*, some *Neoseiulus*, and *Typhlodromus* sp. Type III are generalist predators, namely some Neosseiulus, mostly *Typhlodromus* and *Amblyseius* species, as well as several species from other genera [19]. The presence of prey mites from the tetranychid group (*T. urticae* and *P. citri*), and *B. phoenicis* are favorable conditions for the development of *N. fallacis* to prey on all these phytophagous mites. They can be selective predators that only prey on tetranychid and can be generalist predators which prey to the three phytophagous mites. Tetranychid *T. urticae* and *P. citri* are mite species that make webs. Compared to *P. citri, T. urticae* tetranychid makes the net denser and classified as the most densely forming mite. Such prey mites are suitable for Type II mite predators [19, 20]. The presence of these predatory mites needs to be maintained by not using scheduled pesticides.

All phases of *T. urticae* and *P. citri* mites found in this study were eggs, larvae, nymphs, larvae, resting nymphs, and male and female imago. The phases of *B. phoenicis* mites found are only eggs and female imago. The egg phase is the highest in *T. urticae, P. citri*, and *B. phoenicis* mites (Figure 2). Mite eggs stick to the surface of the leaves that make them difficult to be swept mechanically by rainwater. Huffaker *et al*. [21] stated that plant-eating mites use large amounts of eggs on the substrate of plant parts that are used as larvae feed. The egg phase is the most resistant phase to the environment, especially to hot and dry winds. Therefore, the eggs are most advantaged when unfavorable environmental conditions happen to the phytophagous mites.

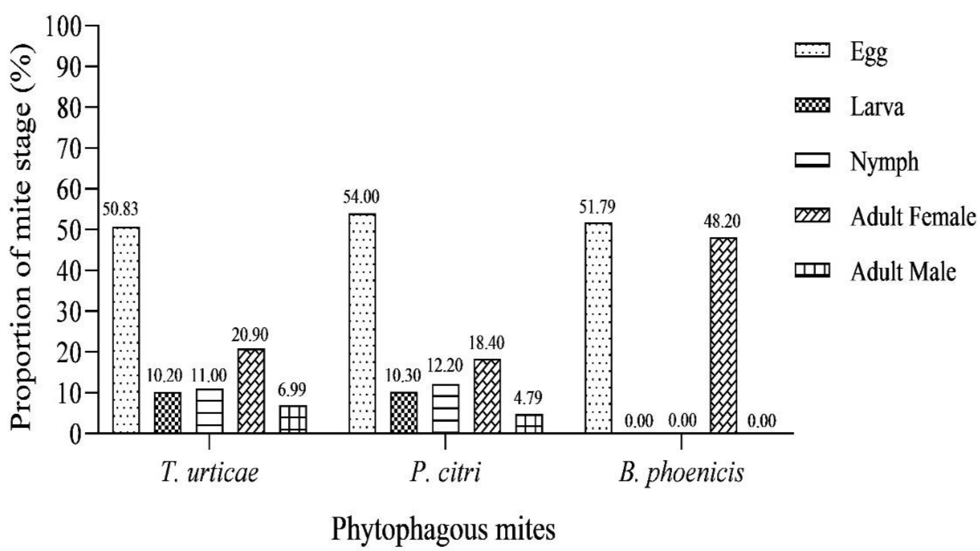

Figure 2 The proportion of phytophagous mites stages on papaya plants in monocultures and polyculture

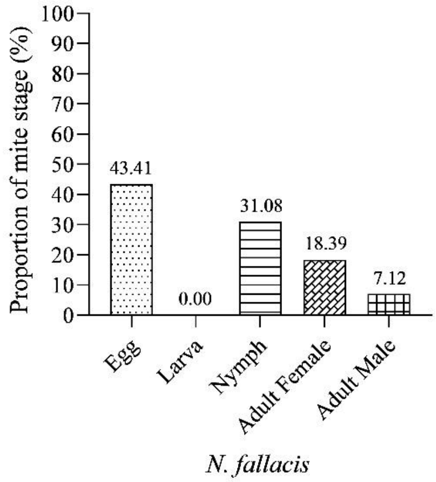

Figure 3 The proportion of *Neoseiulus falacis* stages on papaya plants in monocultures and polyculture

3. CONCLUSION

Three species of phytophagous pest mites *i.e Tetranychus urticae*, *Panonychus citri*, and *Brevipalpus phoenicis*, were found attacking Calina papaya in monoculture and polyculture plantations, additionally predatory mites found was *Neoseiulus fallacis* which act as the indigenous natural enemy. Phytophagous mites tend to live and feed on mature leaves rather than younger ones. Lastly, the population of four species mites in monoculture system was significantly higher than polyculture system.

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