Distribution and population abundance of greenhouse whitefly *Bemisia tabaci* Genn (Hemiptera:Aleyrodidae) on Chrysanthemum

D Hutapea, I B Rahardjo, R P Yanda, and E Diningsih

Indonesian Crops Research Institute, Jl. Raya Cihetang Pacet Cianjur Jawa Barat, Indonesia

Email: dedihutapea03@gmail.com

Abstract. *Bemisia tabaci* Genn. (Hemiptera: Aleyrodidae) is a serious worldwide pest of greenhouse crops on horticultural commodities, especially in chrysanthemum. Besides being able to affect the plant vigor and reduce the quality of chrysanthemums, *B. tabaci* also transmits the plant virus. This study aims to determine the distribution and abundance of whitefly populations in six chrysanthemum cultivars (Sazeta, Nameswari, Cayapati, Yulimar, Kusuma Patria and Sabia) under glasshouse conditions. Numbers of whitely adults, eggs, nymphs and pupa were observed every one week from the underside of the young, mature and old leaves. The total mean numbers of adults, eggs, nymphs and pupa were tested using one-way ANOVA with Tukey’s test at p < 0.05. Our results showed that the population distribution of *B. tabaci* adults in six chrysanthemum cultivars was higher in young leaves than mature and old leaves. Number of eggs and nymphs were higher in mature and old leaves. Whitefly abundance (adults, eggs, nymphs and pupa) on chrysanthemums cultivar Sabia were the highest, implies that there is a need search for appropriate control strategy so that the yield losses of chrysanthemum can be reduced.

1. Introduction

Chrysanthemums (*Dendranthema grandiflora* Tzvlev syn. *Chrysanthemum morifolium*), also called mums or chrysanth are flowering plants of the genus Chrysanthemum in the Asteraceae family. Chrysanthemum is an important ornamental plant in the world known as cut flowers and pot plants. In Indonesia, chrysanthemum is one of the most important flower and the demand continues to increase throughout the year. Ornamental plant production data from BPS-Statistics Indonesia 2016 shows that chrysanthemums are the highest productions compared to orchids, roses, tuberose, anthurium, and gerbera. Chrysanthemum cut flowers are a very versatile flower with varying amounts of usage and many different varieties with variations in sizes, colors and shapes of bloom. Due to high variation on morphotypes make chrysanthemums are popular in the community [1] [2]. Moreover, the wide variations make chrysanthemums suitable for various purposes such as borders, cut flowers, pots plants, bouquets, decorations and for exhibitions [1] [3]. In an effort to increase the production of chrysanthemums, farmers and chrysanthemum producer are often constrained by pests and diseases that cause a decrease in production.

One of the most important pest insects of chrysanthemums is whitefly *Bemisia tabaci* Genn. (Hemiptera:Aleyrodidae). *B. tabaci* is a pest species that causes widespread damage to chrysanthemum and many ornamental crops in greenhouse [4]. There are more than 600 plant species
as a host plant from many field and horticultural crops in greenhouses [5][6]. In the host plant including chrysanthemums, adults and nymphs of B. tabaci causes direct as well as indirect damage. Whitefly causes direct feeding damage by sucking sap. Whitefly adults and nymphs attacks and causes stomatal closure by producing the honeydew on which sooty mould as a result of excretion of nymphs and adults resulting in leaves becoming black and reducing photosynthesis and plant respiration. Severe attacks causes curly leaves, necrosis, miscarriage of leaves, stunted plant growth and decreased crop yields [5] [7] [8]. In addition to direct damage, whitefly is a vector of many plant viruses such as Begomovirus and Crinivirus [4] [9].

B. tabaci is an invasive species which distribution has increased since it was first detected in Indonesia in 1938 [10] and has grown rapidly in greenhouse crops. Appropriate climatic conditions, altitude, endosymbionts, abundance of host plants both cultivated plants and weeds by now trigger an increase in this pest population [11] [12]. B. tabaci can attack chrysanthemums at all stage levels (vegetative and generative) and this certainly reduces the productivity of chrysanthemums and even causes losses to farmers. Amount of damage due to whitefly ranged between 20-100% [13], depend on the condition of the season and plants both in the field and in the greenhouse [5] [14]. Various methods have been explored to resolve B. tabaci attack including the synthetic insecticides. Management of agricultural ecosystems with implementing good agricultural practices and integrated pest management adequate to obstruct the development of population of plant disturbing organisms. To understand the increase in population and appropriate control of B. tabaci, it is necessary to study agroecology and biodiversity in chrysanthemum agroecosystem. This information are needed to optimize control and minimize losses caused by B. tabaci [15][16]. In Indonesia, information pertaining to the distribution and abundance of B. tabaci population in chrysanthemum plants is still limited. This lack of information is one of the causes of non-optimal pest control by farmers and chrysanthemums producer. Therefore, the objective of study was to determine the distribution and abundance of whitefly populations of B. tabaci on some chrysanthemum cultivars to provide scientific bases for determining the stability of the B. tabaci community in spatial and temporal scales on chrysanthemum plants.

2. Materials and Methods
The study was conducted at the Entomology Laboratory and Greenhouse of Pest and Disease Indonesian Ornamental Crops Research Institute (IOCRI) an altitude of 1100 m asl from June to September 2017. The experiment was arranged in completely randomized design with 6 cultivars of chrysanthemum (Nameswari, Sazeta, Cayapati, Yulimar, Kusuma Patria, and Sabia) and five replications. Pot planting media used include soil, bamboo litter, horse manure, and husk charcoal. Each chrysanthemum cultivar has been planted in a pot sized 10 cm x 13 cm as much as one plant per pot. The addition of light is carried out for 4 hours every day from 7:00 a.m. to 11:00 p.m. since the planting up to 4 weeks after planting. The addition of light uses a lamp 40 watt warm light and is set with a timer. The distance between the lights is 3 m and the height of the lamp is 1.5 m from the plant canopy. The addition of light is done to increase the length of the day and help the vegetative growth of chrysanthemum. Chrysanthemum upkeep was conducted by watering, weeding and giving NPK fertilizer (15:15:15) with a dose of 2 grams/plant.

2.1. B. tabaci rearing and sampling
The initial coloni of B. tabaci adults used in these experiments were obtained from gerbera (Gerbera jamesonii) in the greenhouse and identified at the Entomology Laboratory IOCRI. These pest colonies were reared in the chrysanthemum with cages containing with an average temperature of 21°C and a relative humidity of 70% to be available for all treatments. 400 imminations of whitefly were released in all chrysanthemums in the greenhouse [17]. Then 48 hours after infestation, whitefly infestation population was calculated randomly on three plants per replication (young leaves, mature leaves, and old leaves) on the lower surface of the leaf [18]. Observation of the population distribution of B. tabaci (adults, eggs, nymphs and pupa) was carried out every 7 days on the surface of the sample plant
(young leaves, mature leaves, and old leaves). Samples of chrysanthemum leaves that will be observed are placed in plastic and observed in the laboratory. The number of eggs, nymphs and pupa of whitefly was observed using a stereo microscope at 40x magnification.

2.2. Statistical analysis

Data on the number of eggs, nymphs, pupa and adults whitefly on each cultivar were transformed using the formula: \( \sqrt{x + 0.5} \), where \( x \) is the number of eggs, nymphs, pupa and adult whitefly. Experimental data were analyzed by one-way ANOVA and the comparison of the mean values of the treatment was tested by the Tukey test (\( P <0.05 \)). All the comparison data above were analyzed using version 17 of the Minitab Statistical Package program.

3. Results and Discussion

3.1. Distribution of B. tabaci on chrysanthemum

Distribution of \( B. tabaci \) (adult, pupa, nymphs and eggs) in chrysanthemum was calculated based on three parts of chrysanthemum leaves (young leaves, mature leaves and old leaves). The results of observations on adult distribution, eggs, nymphs, and pupa \( B. tabaci \) on six chrysanthemum cultivars from the first day of infestation to one weeks after infestation (WAI) showed a dynamic population distribution. This indicates that whitefly adult has a high mobility to move and feed from one plant to another. Two chrysanthemum cultivars (Sabia and Yulimar) were consistently perched with whitefly adult in the young leaves with an average number of 17-24 population per plant. While four other chrysanthemum cultivars showed inconsistent whitefly distribution, sometimes they were perched on the first day of release but moved on the next day. The six chrysanthemum cultivars tested, none of the cultivars that were not infested by whitefly (0 per plant). These indicate that all chrysanthemum cultivars have the opportunity to transmit the virus because greenhouse whitefly has the potential vector to transmit the chrysanthemum Begomovirus [19].

In general, the distribution of whitefly populations in three leaves part of six chrysanthemum cultivars only in young leaves showed a significant difference (\( p <0.05 \)) compared to mature and old leaves. The whitefly adult stage was seen most commonly in the young leaves compared to two other parts (Figure 1). The highest adult population of \( B. tabaci \) was found in Sabia cultivars with an average number of 20-24 whitefly per plant and were significantly different compared to the other five chrysanthemum cultivars. While at the eggs stage, only Yulimar cultivars in the mature leaves showed significant differences (\( p <0.05 \)) with an average of 5-6 eggs per plant (Table 1).

![Figure 1. Distribution of adult whitefly B. tabaci on young leaves (A), mature leaves (B), and nymphs on mature leaves chrysanthemum.](image-url)
Table 1. Distribution of adults, eggs, nymphs and pupa stage of *B. tabacci* on leaf stage chrysanthemum.

| Cultivar   | Leaf stage | Whitefly Stage Population |
|------------|------------|---------------------------|
|            |            | Adults | Eggs | Nymphs | Pupa |
| Nameswari  | Young leaves | 4.916 ± 0.231 b | 0.000 ± 0.000 b | 0.000 ± 0.000 a | 0.000 ± 0.000 a |
|            | Mature leaves | 0.333 ± 0.023 cd | 0.500 ± 0.028 b | 0.254 ± 0.025 a | 0.000 ± 0.000 a |
|            | Old leaves | 0.000 ± 0.000 d | 0.000 ± 0.000 b | 0.750 ± 0.047 a | 0.334 ± 0.023 a |
| Sazeta     | Young leaves | 2.667 ± 0.527 b | 0.250 ± 0.025 b | 0.000 ± 0.000 a | 0.000 ± 0.000 a |
|            | Mature leaves | 0.416 ± 0.315 cd | 1.000 ± 0.108 b | 0.250 ± 0.025 a | 0.000 ± 0.000 a |
|            | Old leaves | 0.000 ± 0.000 d | 0.000 ± 0.000 b | 0.250 ± 0.025 a | 0.250 ± 0.025 a |
| Cayapati   | Young leaves | 7.334 ± 1.082 b | 0.753 ± 0.478 b | 0.000 ± 0.000 a | 0.000 ± 0.000 a |
|            | Mature leaves | 0.250 ± 0.083 cd | 1.500 ± 0.346 b | 1.000 ± 0.070 a | 0.000 ± 0.000 a |
|            | Old leaves | 0.000 ± 0.000 d | 0.250 ± 0.083 b | 0.500 ± 0.124 a | 0.500 ± 0.288 a |
| Yulimar    | Young leaves | 17.083 ± 1.012 b | 1.500 ± 0.288 b | 0.000 ± 0.000 a | 0.000 ± 0.000 a |
|            | Mature leaves | 3.168 ± 0.129 b | 5.753 ± 0.702 a | 1.750 ± 0.364 a | 1.500 ± 0.190 a |
|            | Old leaves | 0.000 ± 0.000 d | 1.000 ± 0.018 b | 1.000 ± 0.401 a | 0.333 ± 0.024 a |
| Kusuma     | Young leaves | 3.583 ± 0.212 b | 0.000 ± 0.000 b | 0.000 ± 0.000 a | 0.000 ± 0.000 a |
| Patria     | Mature leaves | 0.000 ± 0.000 d | 0.250 ± 0.021 b | 0.946 ± 0.103 a | 0.167 ± 0.061 a |
| Sabia      | Young leaves | 20.167 ± 4.855a | 0.750 ± 0.047 b | 0.000 ± 0.000 a | 0.000 ± 0.000 a |
|            | Mature leaves | 2.667 ± 0.163bc | 3.500 ± 0.256 b | 2.250 ± 0.108 a | 0.500 ± 0.089 a |
|            | Old leaves | 0.833 ± 0.083 cd | 0.700 ± 0.021 b | 1.750 ± 0.280 a | 1.083 ± 0.138 a |

Means within the same column followed by the same letter are not significantly different using Tukey’s test ($\alpha = 0.05$).

The average population number of nymph and pupa stages in all chrysanthemum cultivars has an almost uniform. Adults and eggs distribution pattern tend to be found on the young leaves and mature leaves. While the pattern of nymph and pupa distribution has a tendency in the mature leaves and old leaves in all chrysanthemum cultivars. The results of this study revealed that adults of *B. tabacci* preferred young leaves and mature leaves to lay eggs compared to old leaves. This preference causes that young and mature leaves are more lenient, and nutritional quality is better than old leaves. The other studies also showed that *B. tabacci* adults on tomatoes [5], pepper [20] and eggplant [21] preferred young leaves for feeding process, oviposition and perching. Host plant selection including among initial infestation and chrysanthemum sensitivity with the presence of nutritional content in the form of chemical compounds in chrysanthemum leaves are factors that influence the attractiveness of greenhouse whitefly. Morphological characteristics of leaves that affect infestation and oviposition of *B. tabacci* in plants include; leaf width, lamina thickness and leaf color, leaf trichoma density, trichome length, sugar content in trichomes, plant protein content, chemical content such as $\alpha$-tocophenol, squalene, and linolenic acid [5] [20] [21][9].

3.2. Abundance of *B. tabacci* populations on chrysanthemum

The abundance of *B. tabacci* population has varying dynamics in each chrysanthemum cultivar ranging from one WAI to four WAI. Whitefly population development tends to increase until the plant grows larger. The observations show that as plants grow, the number of adults, eggs, nymphs and pupa of whitefly continue to grow until the generative phase. Based on data analysis it was found that the mature and immature of *B. tabacci* were higher in Sabia cultivars and were significantly different (p <0.05) compared to five other chrysanthemum cultivars. While the lowest number of adults, eggs, nymphs and pupa were found in Sazeta cultivars (Table 2). The high abundance of *B. tabacci*
population in Sabia cultivars compared to other chrysanthemum cultivars due to the condition of this plant was quite promote for whitefly survival.

**Table 2.** Total mean (± SE) abundance of adults, eggs, nymphs and pupa *B. tabaci* on chrysanthemum.

| Cultivar     | Number of adults per plant | Number of eggs per plant | Number of nymphs per plant | Number of pupa per plant |
|--------------|-----------------------------|--------------------------|---------------------------|--------------------------|
|              | 1 WAI<sup>a</sup> | 2 WAI | 3 WAI | 4 WAI | 4 WAI | 4 WAI |
| Nameswari    | 1.000 ± 0.0137 ab<sup>b</sup> | 1.500 ± 0.016 b | 2.000 ± 0.085 b | 1.417 ± 0.067 b | 0.521 ± 0.080 c |
| Sazeta       | 0.250 ± 0.087 b        | 0.917 ± 0.004 b         | 1.667 ± 0.019 b       | 1.250 ± 0.083 b       | 0.562 ± 0.121 c |
| Cayapati     | 1.250 ± 0.113 ab       | 1.750 ± 0.016 b         | 2.417 ± 0.044 b       | 3.333 ± 1.246 ab      | 0.708 ± 0.267 c |
| Yulimar      | 1.583 ± 0.447 ab       | 3.583 ± 0.219 ab        | 4.917 ± 0.206 ab      | 5.420 ± 0.330 ab      | 1.958 ± 0.517 b |
| Kusuma Patria| 0.500 ± 0.063 b        | 1.250 ± 0.021 b         | 1.833 ± 0.012 b       | 2.750 ± 0.660 b       | 0.875 ± 0.043 c |
| Sabia        | 3.250 ± 1.210 a        | 9.580 ± 0.622 a         | 8.670 ± 0.581 a       | 7.580 ± 0.550 a       | 2.917 ± 0.476 a |
|              | **F-value**           | **3.53**               | **3.86**               | **3.74**               | **5.53**             | **19.34** |
|              | **P-value**           | **0.007**              | **0.004**              | **0.005**              | **0.000**            | **0.000** |

| Cultivar     | Number of nymphs per plant | Number of pupa per plant |
|--------------|-----------------------------|--------------------------|
|              | 1 WAI<sup>a</sup> | 2 WAI | 3 WAI | 4 WAI | 4 WAI |
| Nameswari    | 0.000 ± 0.000 a        | 0.250 ± 0.007 b         | 0.750 ± 0.017 b       | 2.083 ± 0.252 b       | 0.208 ± 0.016 b     |
| Sazeta       | 0.000 ± 0.000 a        | 1.083 ± 0.017 b         | 1.583 ± 0.033 b       | 1.083 ± 0.074 b       | 0.117 ± 0.034 b     |
| Cayapati     | 0.000 ± 0.000 a        | 0.583 ± 0.067 b         | 1.083 ± 0.083 b       | 1.667 ± 0.016 b       | 0.208 ± 0.016 b     |
| Yulimar      | 0.083 ± 0.013 a        | 2.417 ± 0.159 b         | 4.420 ± 0.492 ab      | 6.750 ± 0.921 a       | 0.792 ± 0.418 b     |
| Kusuma Patria| 0.000 ± 0.000 a        | 0.750 ± 0.057 b         | 1.667 ± 0.026 b       | 2.083 ± 0.252 b       | 0.312 ± 0.061 b     |
| Sabia        | 0.417 ± 0.194 a        | 5.080 ± 0.383 a         | 7.080 ± 0.176 a       | 8.000 ± 0.495 a       | 1.750 ± 0.375 a     |
|              | **F-value**           | **2.24**               | **8.37**               | **6.66**               | **10.46**            | **10.82** |
|              | **P-value**           | **0.061**              | **0.000**              | **0.000**              | **0.000**            | **0.000** |

<sup>a</sup>weeks after infestation

<sup>b</sup>The same value in the same column (mean ± SE) and followed by different letters shows a significant difference based on Tukey's test at the 5% level.

Based on observations, it seems that the number and width of leaves on Sabia cultivars affected the level of *B. tabaci* host plants selection to perch on chrysanthemums, especially on the first day after release. The highest total number of leaves and leaf area from six chrysanthemum cultivars were found in Sabia (24.42 sheets and 7.54 cm) and the lowest was in Kusuma Patria cultivars (Table 3). These indicates that Sabia cultivars are preferred to *B. tabaci*. Adequate feed requirements are the key factor in the abundance of *B. tabaci* in Sabia cultivars. Furthermore, the high whitefly population in Sabia cultivars were also influenced by the morphological characters of the plant, including among; leaf structures, shape and position of leaves, and trichome densities that are preferred for feeding and oviposition activities. According to [21] the morphological characteristics of the leaves became the determining factor for intra-varietal preference of *B. tabaci*. Variations and leaf trichome density also indicated plant resistance to oviposition of *B. tabaci* [22]. In addition to feeding factors, the abundance of *B. tabaci* was also influenced by the ability to reproduce and be supported by appropriate environmental conditions. Based on this informations, it means that the high and low whitefly population still causes damage to chrysanthemum leaves and resulting in photosynthetic barriers. Thus, the presence of whitefly in chrysanthemum production must be considered.
Table 3. Morphological characteristics of six chrysanthemum cultivars.

| Cultivar       | Plant height (cm) | Number of leaves (sheet) | Leaf length (cm) | Leaf area (cm) |
|----------------|-------------------|--------------------------|------------------|----------------|
| Nameswari      | 40.43             | 19.25                    | 7.80             | 5.39           |
| Sazeta         | 33.05             | 21.10                    | 6.52             | 5.57           |
| Cayapati       | 36.68             | 22.08                    | 5.20             | 5.61           |
| Yulimar        | 41.33             | 21.25                    | 6.21             | 6.42           |
| Kusuma Patria  | 40.76             | 15.50                    | 7.97             | 5.27           |
| Sabia          | 44.62             | 24.42                    | 7.40             | 7.54           |

The results of this study revealed that Sabia cultivars are more susceptible to whitefly infestation *B. tabaci* than other chrysanthemum cultivars. Meanwhile, Sazeta, Nameswari, Cayapati, Kusuma Patria and Yulimar cultivars were indicated to be more resistant to whitefly infestation. Based on the results of this study indicate that whitefly resistant cultivars can be an alternative in providing a real contribution to the increase in chrysanthemum cut flower production. The use of resistant varieties is one of the strategies in the principle of integrated pest management (IPM) [23]. This can be a consideration in preventing damage and loss of yields of chrysanthemums as a result of attacks by whitefly in greenhouses. Using resistant chrysanthemum varieties can be an effective, economical and environmentally friendly method to control whitefly. Prevention methods can be a cost-effective and efficient tool for pest control. The use of rational prevention methods is a feasible way to reduce synthetic insecticides in agriculture. Furthermore, the interesting thing about using resistant varieties is that farmers do not need for a particular skills in application techniques and there is no cash investment by resource-poor farmers [24].

![Figure 2. Chrysanthemum cultivars of Nameswari (A), Sazeta (B), Cayapati (C), Yulimar (D), Kusuma Patria (E), and Sabia (F)](image-url)
4. Conclusion
From this study, we have shown that the population distribution of *B. tabaci* infestation in six chrysanthemum cultivars was higher in young leaves compared to mature leaves and old leaves. Population number of eggs and nymphs whitefly are higher in mature and old leaves. In respect to *B. tabaci* abundance on chrysanthemums cultivar or varieties, cultivar Sabia were the highest in the number of adults, eggs, nymphs and pupa populations. These phenomenon shows that the known distribution and abundance of whitefly populations in chrysanthemum was expected to composed an appropriate control strategy so that the yield losses of chrysanthemum can be reduced.

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