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Population abundance of alate whitefly, (*Bemisia tabaci* Gennadius) in chilli (*Capsicum annuum* L.) ecosystem

[Kelimpahan populasi lalat putih bersayap, (*Bemisia tabaci* Gennadius) pada ekosistem pokok cili (*Capsicum annuum* L.)]

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Keywords: alate *Bemisia tabaci*, environmental factors, population dynamics, chilli

Abstract

The population abundance of alate whitefly (WF) (*Bemisia tabaci* Gennadius) on chilli (*Capsicum annuum* L.) was studied. A yellow sticky trap (YST) was used to monitor the population at MARDI Station, Jalan Kebun, Selangor from July to October 2003. The mean number of WF per YST was significantly different among the sampling dates ($F = 16.52$, df = 15 and 112, $p < 0.05$). The number of WF per YST was highest at 77 days after transplanting (DAT) and lowest at 7 DAT, which differed significantly ($p < 0.05$) from the rest of the sampling dates. The environmental factors namely the rainfall amount ($r = -0.186$, $p > 0.05$), sunshine duration ($r = 0.156$, $p > 0.05$), and relative humidity ($r = -0.443$, $p > 0.05$) had no significant relationship with abundance of alate WF. However, wind speed had a strong and positive relationship ($r = 0.806$, $p < 0.05$) with the abundance of alate WF. Similarly, there was no significant relationship ($r = 0.321$, $p > 0.05$) between the number of alate WF caught on YST and crop maturity. Result of this study revealed that YST could be used to monitor WF population in chilli field ecosystem.

Introduction

The whitefly, *Bemisia tabaci* (Gennadius) (Homoptera: Aleyrodidae) is polyphagous and feeds on 600 host plant species belonging to 77 families including vegetables, field crops and ornamental plants (Basu 1995; De Barro 1995; Gerling and Kravchenko 1996; Secker et al. 1998). It is a major pest of cotton, tomato, cucumber, watermelon, squash, eggplant, peppers, beans and cabbage (McAuslane 2002).

According to Brown (1994) and Campbell et al. (1996), there are about 1,200 species of whitefly (WF) that have been recorded so far, and only three are recognized as vectors of plant viruses namely *B. tabaci* (Russell 1957), *Trialeurodes vaporariorum* (Westwood) and *T. abutilonea* (Hald). However, *B. tabaci* is considered the most important vector, and is associated with more than 100 viral diseases mainly in the tropics and subtropics (Varma 1963; Mound 1983; Duffus 1987; Cock 1993; Nault 1997).

During the past decade, WF has become a prominent problem worldwide

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especially in the subtropical agro-ecosystems. Millions of dollars have been lost as a result of direct damage, honeydew contamination, and fungal growth and virus diseases caused by WF-transmitted geminiviruses (Costa and Brown 1991; Cohen et al. 1992). Since then, the number of *B. tabaci* transmitted plant viruses has escalated and the total yield loss of important food and industrial crops has also increased (Oliveira et al. 2001).

The economic damage caused by this pest in the USA in 1991 was estimated at over US$500 million (Costa and Brown 1991). Environmental factors play important roles in the distribution and abundance of insect (Nechols et al. 1999), biotic potential (Honek 1996), fecundity (Frazer and McGregor 1992), rate of development (Doerr et al. 2002; He et al. 2003), behaviour as well as the form and structure of an insect species (Andrewartha and Birch 1954).

Studies on the population dynamics of *B. tabaci* have received attention in recent years, matching with its growing stature as a very formidable pest, especially on cotton. Although many studies on WF have been conducted on vegetable crops, there is still lack of information on the population abundance of WF on chilli (*Capsicum annuum* L.) crop, particularly in Malaysia. Therefore, the objectives of this study were to investigate the population abundance of alate WF and to determine factors that influence the pattern of WF population in chilli.

Materials and methods

Study site

This study was conducted at MARDI Station Jalan Kebun, Klang, Selangor (5 July–18 October 2003). The Station was situated on a flat oligotropic peat land, between 3° N latitude and 101° 4´E longitude and 3.1 m above sea level. The pH of the soil ranged from 5.5–6.5.

Source of chilli

Chilli cultivar MC11 was obtained from MARDI Station Jalan Kebun. This chilli variety is characterized by the erect and open plant architecture (Idris and Mohamad Roff 2002). The leaves are alternate, simple, petiole up to 10 cm long, ovate in shape and light to dark green in colour. The height of the plant is between 100–200 cm. The chilli MC11 is one of the popular varieties planted by farmers in Malaysia.

Experimental layout

Three plots (replicates), each measuring 10 m x 10 m, were used in this study. The plots were separated by 5 m border from each other. There were eight raised beds (0.15 m high x 0.6 m wide) in each plot. Chilli seeds were sown in ‘speedling trays’ and placed in an insect proof nursery. At 45 days after sowing, a total of 384 seedlings (10–15 leaves stage and 15–20 cm tall) were transplanted to the plots. A total of 16 chilli seedlings were planted on each bed, at a distance of 0.6 m within row and 1.0 m between rows. Compound fertilizer, NPK Blue Special (12:12:17.2) was applied at 30 g per plant per application per month for 3 months. No insecticide or weedicide was applied to avoid any effect on the WF population during the experimental period.

Alate whitefly trapping

A total of 24 yellow sticky traps (YST) (eight traps per replicate), 20 x 15 cm in size, were placed randomly in each replicate to trap the WF. Each YST was covered with a transparent polyvinyl chloride (PVC) plastic bag (0.25 mm). The traps were sprayed with glue (Neopeace-F 101 containing Polybutene 32% w/w) on one side when placed in the field.

Each YST was hanged on a wooden pole just above the canopy of the chilli plant between beds in each replicate. The binder clips (double clips, size 0.75") were used to fix the YST on the wooden pole. The position of the YST was changed according to plant height from time to time.

The traps were left for one week in the field, then collected, labelled and brought back to the laboratory for WF counts. The number of WF was counted by placing YST on top of a black background. The transparent PVC plastic was divided into several small quadrates (1 cm x 1 cm) and numbered before counting of WF.

Environmental data

Environmental data such as sunshine duration (h/d), relative humidity (%), wind speed (km/h) and rainfall amount (mm/d) were obtained from the Meteorological Station, MARDI Station Jalan Kebun. The Meteorological Station was located in an open area 200 m from all the experimental plots. Sunshine duration was recorded by crystal ball (Casella London, MKIIIA 0–40, 19970), wind speed by odometer (Casella London, W5822, 1970), relative humidity and rainfall (mm/d) by rain gauze (Rainfall Sensor, DRC-100 RS 000104, George Kent, Malaysia Berhad, 2000).

Analysis of data

Data of alate WF were transformed using $\sqrt{x + 0.5}$ (Healy and Taylor 1962) for normalization before analysis. To determine the difference in the number of WF per YST among observation dates, one-way analysis of variance (ANOVA) was performed. Means were separated with Fisher's Protected Least Significant Difference (LSD, p <0.05) where ANOVA result was significant. To evaluate the influence of climatic factors on the number of WF trapped on YST, the correlation and linear regression analysis were done. Data was statistically analysed using Minitab Statistical Package Programme (Minitab 13.2., 2002).

Results

The mean number of alate WF per YST was different significantly ($F = 16.52$ df = 15, 112, p <0.05) among the sampling dates. The number of WF was significantly higher (p <0.05) in the middle than in the early and late of planting seasons. The number of alate WF trapped was lowest at 7 days after transplanting (DAT) (during the initial cropping stage) and peak at 63 DAT (*Figure 1*). Overall, the number of WF trapped increased steadily from 7 to 35 DAT, then increased at a faster rate from 35–42 DAT, and increased again at a steady rate between 42–70 DAT. The WF abundance then decreased sharply from 63 to 77 DAT and steadily declined from 77 DAT onward.

The number of alate WF had no correlation with mean hour sunshine per day ($r = 0.156$, $F = 0.35$, df = 1, 14, p >0.05), mean rainfall intensity ($r = -0.188$, $F = 0.51$, df = 1, 14, p >0.05) and mean relative humidity per day ($r = -0.443$, $F = 3.43$, df = 1, 14, p >0.05). However, total wind speed (km/h/d) was positively and significantly ($r = 0.806$, $F = 25.97$, df = 1, 14, p <0.05) correlated with the number of captured alate WF at all observation dates (*Figure 1*). The regression for wind speed $Y = 32.2 + 3.40x$ revealed that with 3.40 km/h/d increase in wind speed, the number of alate WF trapped per YST increased by 32.2. The regression analysis also indicated that there was no significant relationship between plant maturity and number of alate WF trapped ($r = 0.32$, $F = 1.61$, df = 1, 14, p >0.05) (*Figure 2*).

Discussion

The number of alate WF trapped was varied significantly among the observation dates (*Figure 1*). The number of WF increased to a peak at the earlier cropping period but declined towards the end of the cropping period. Meyerdirk et al. (1986) reported similarly relatively low number of alate population at the early stages of the cropping cycle which increases in the middle but declines towards the end of the cropping cycle in alfalfa crop. This result together with the result of this study are in agreement with the findings of Gerling et al. (1980) who suggested such population trend might be related with the physiological conditions of the plant.

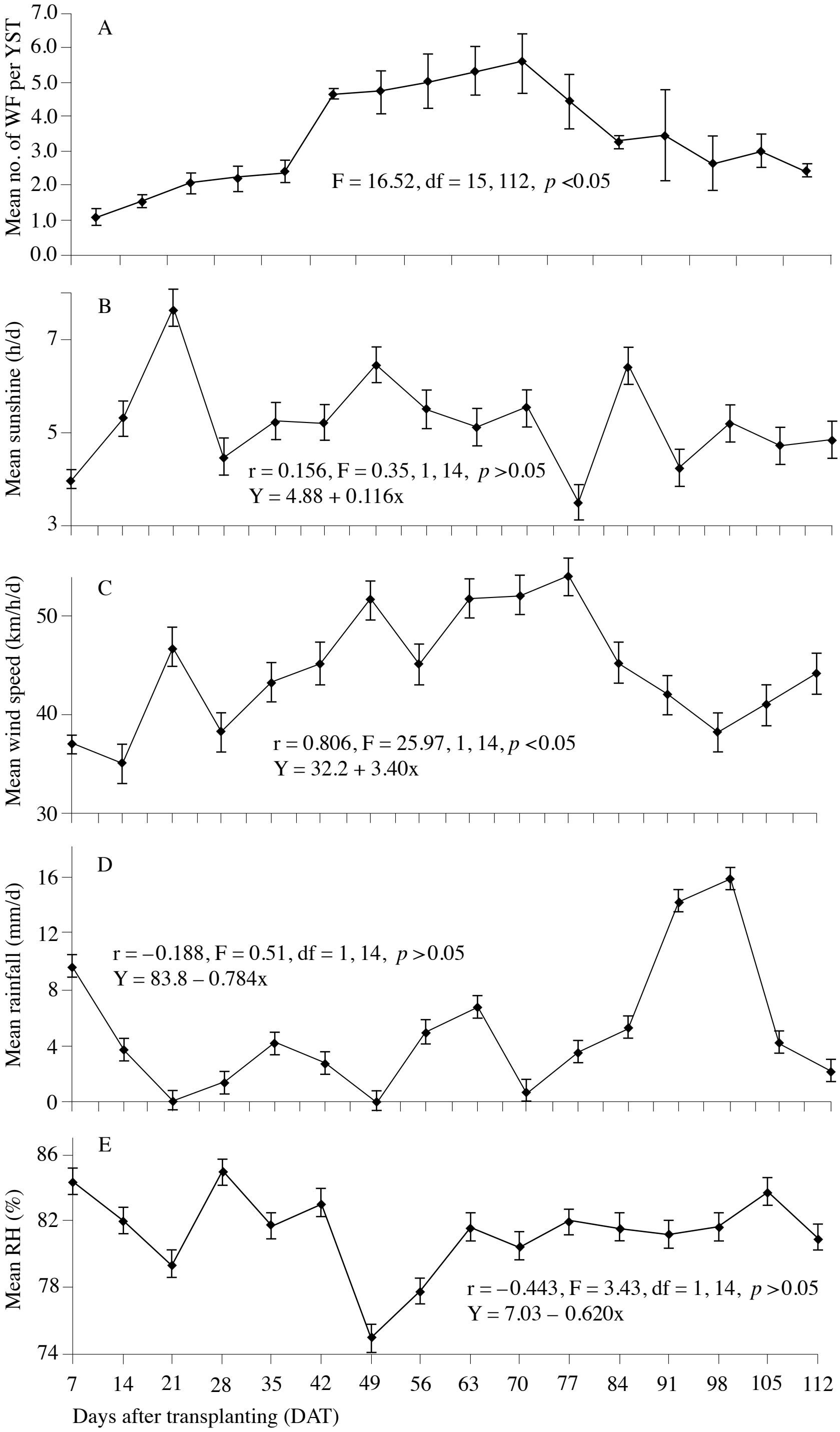

Figure 1. The abundance of WF (A) and the relationship between abundance of alate WF per YST with sunshine intensity (B), wind speed (C), rainfall intensity (D) and relative humidity (E)

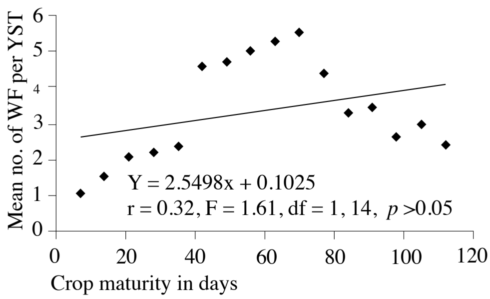

Figure 2. Relationship between crop maturity stages (days after transplanting) and mean numbers of alate WF

This might be true because at the mid-season or fruiting stage, the higher carbohydrate and amino acid concentration are available thus influence the reproduction rate which therefore resulted in high population of *B. tabaci* (Palumbo et al. 2000). The reason was based on their findings that the population of WF, *B. tabaci* on cotton was lowest at the initial growth stage, and gradually increased until it reached a peak at the end of mid-cropping period before dropping again. In addition to that, increase in alate WF is not related to an increase in abundance of WF per plant, but rather to the increase in host foliage available in mid-season according to Bellows and Arakawa (1988).

Whereas, other studies showed that the trend of population abundance of WF can also be influenced by the senescence stage of the plant (Van Gent 1982). Natural enemies normally present in high number when prey population are high in the middle stage of cropping cycle and keep the WF population declines towards the end of mid-season. They reported that even though the natural enemies were not available during the end of the middle cropping cycle, but still the population of alate, *B. tabaci* gradually decreased.

In cotton, the number of alate, *B. tabaci* increased from very low levels at the start of the season to exceptionally high population later in the season. They found that throughout the season, the relative proportion of mature instars increased as the season progressed. In the late cropping cycle, the population decreased again due to the presence of natural enemies. Coudriet et al. (1985) also reported the lower WF population at the beginning of the crop cycle, higher in the middle and again lower in the late cropping cycle.

Plant quality might also influence the population of WF. According to Slosser et al. (1992), the abundance of bandedwinged WF, *Trialeurodes abutilonea* (Haldeman) (Homoptera: Aleyrodidae) was negatively correlated with percentage of moisture and nitrogen content in cotton leaves. The values were usually high in the young plant but relatively low in the mature plant, which positively affected the high population abundance of alate WF (Slosser et al. 1992). However, the plant quality in late season deteriorated and plant became more resistant, and thus reduced the population of alate WF in the late season.

The results indicated that the environmental factors like sunshine duration hour, rainfall amount and relative humidity had no relationship with alate WF population, while wind speed had positively correlated with the alate WF (*Figure 1*). The alate WF trapped on YST was high when wind speed was over 45 km/h/d indicating that wind speed ≥45 km/h/d carried the alate WF from the plant which later was trapped on the YST. This suggests that strong wind might be responsible for carrying alate WF away from the plants or it colonies as well as from surrounding vegetations.

Mohanty and Basu (1991) also reported that the alate *B. tabaci* trapped was negatively correlated with rainfall amount. They reported that the number of alate WF trapped was very low after heavy rain. On the other hand, in long sunshine duration hour, the alate WF trapped was high.

The results showed that there was no correlation between mean sunshine duration hour and number of alate WF trapped. This suggests that sunshine does not necessarily influence the abundance of alate WF

(*Figure 1*). El-Helaly et al. (1977) reported that in 16/8 light/dark condition, the development of nymphal stage of WF was faster. They reported that if the immature stages exposed at 8 h of 16 h in light, their development became faster.

Relative humidity did not show any significant influence on the number of WF trapped (*Figure 1*). The percentage of alate WF survived is less when relative humidity is 21% or between 21% and >90% (Cohen 1982). Gerling et al. (1986) reported that higher humidity caused death to WF, and that the survival of alate WF was low at humidity ≤45% and ≥85%. However, RH in this study was relatively constant during the study period (74.93 ± 3.60 – 84.63 ± 3.78) and that survival effect could not be seen as the number of WF was low throughout the season.

The results also indicated that alate WF abundance had no correlation with crop maturity (*Figure 2*). This suggests that crop maturity is not a major factor influencing alate WF population. The fluctuation of the population might be influenced by other factors such as weather, plant vigour, surrounding vegetation as well as wind.

Plant health and vegetation present in and surrounding the field can be manipulated for the management of insect pests such as WF (Altieri and Nicholls 2004; Mensah and Sequeira 2004). The effect of wind on alate WF movement could also be limited or deterred by correct inter-planting of crops such as maize within many crop ecosystems (Mensah and Sequeira 2004).

However, further studies need to be conducted to elucidate the main factors responsible for the alate WF population on chilli and to test the effect of surrounding vegetations and diversity in the chilli ecosystem on the population dynamics of WF.

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Abstrak

Kelimpahan populasi lalat putih bersayap (*Bemisia tabaci* Gennadius) pada pokok cili (*Capsicum annuum* L.) telah dikaji. Perangkap lekit kuning (YST) digunakan untuk memantau populasi di Stesen MARDI, Jalan Kebun, Selangor dari Julai hingga Oktober 2003. Jumlah purata lalat putih per YST berbeza secara signifikan antara waktu pensampelan ($F = 16.52$, df = 15 and 112, $p < 0.05$). Jumlah lalat putih per YST adalah tertinggi pada hari ke-77 selepas penanaman (DAT) dan terendah pada hari ke-7 DAT, dan ini berbeza secara signifikan ($p < 0.05$) dengan tempoh pensampelan yang lain. Fakor persekitaran seperti jumlah hujan ($r = -0.186$, $p > 0.05$), tempoh sinaran matahari ($r = 0.156$, $p > 0.05$) dan kelembapan bandingan ($r = -0.443$, $p > 0.05$) tidak mempunyai hubungan yang signifikan dengan kelimpahan populasi lalat putih bersayap. Walau bagaimanapun, kelajuan angin mempunyai korelasi yang kuat dan positif ($r = 0.806$, $p < 0.05$) dengan kelimpahan populasi lalat putih. Namun begitu, tiada hubungan yang signifikan ($r = 0.321$, $p > 0.05$) antara bilangan lalat putih bersayap yang diperangkap dengan kematangan pokok cili. Hasil kajian ini menunjukkan YST boleh digunakan untuk memantau populasi lalat putih bersayap dalam ekosistem pokok cili.

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