Research article

Influence of Meteorological Parameters on Population of Whitefly, *Bemisia tabaci* on Greenhouse-grown Tomatoes

KANCHANA THINNABUT
Department of Entomology and Plant Pathology, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

DUANGRAT THONGPAK
Department of Entomology and Plant Pathology, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

CHUTINAN CHOOSAI
Department of Entomology and Plant Pathology, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand

UBON TANGKAWANIT*
Department of Entomology and Plant Pathology, Faculty of Agriculture, Khon Kaen University, Khon Kaen, Thailand
Email: Ubonta@kku.ac.th

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Abstract Whiteflies (*Bemisia tabaci* (Gennadius)) are important vectors of diseases of tomato crop production. Outbreaks of whiteflies can cause decreased productivity and transmit pathogens. The purposes of this study were to compare the degree of white fly infestation in two varieties of tomatoes, Shiny Queen and Ninmanee, and to investigate whitefly population responses to weather-related environmental parameters. The study was conducted in a green house. Whitefly population was counted every two days on three positions of the plant; the upper part, middle part and lower part. The results indicated that the Shiny Queen variety was infected with significantly higher numbers of white fly than was the Ninmanee variety. Whitefly numbers observed on Shiny Queen variety were significantly related to temperature, relative humidity, solar radiation and dew point. A mathematical model was developed to predict the relationship of environmental conditions to white fly population.

Keywords weather parameters, abiotic factors, Aleyrodidae

INTRODUCTION

The whitefly *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) is an important pest on tomato. It can cause direct damage to the crop by puncturing the leaf tissue and feeding on the phloem resulting in reduced growth rate and yield. In addition, it can transmit tomato yellow leaf curl virus (TYLCV) (Liu et al., 2013). The common cultivated tomato (*Solanum esculentum*) is very susceptible to TYLCV. Infected tomato plants show symptoms of yellowing, curling, and cupping of leaves. Additionally, this virus causes a severe stunting and abortion of flowers and fruits, leading to 100% yield loss (Yan et al., 2018). The production of honeydew by the whitefly can causes stickiness and promotes growth of mold. *B. tabaci*, eggs nymphs and adults are found on the underside of leaves where they are protected from applications of insecticides. Production of vegetables in greenhouses is practiced worldwide and it can protect crops from abiotic factors such as wind, rain, and temperature that may damage to the crop. It may protect crops from many diseases, and some common field pests. The largest area of greenhouse cultivation occurs in Asia, with China having 55% of the total world's plastic greenhouse acreage (including large plastic tunnels) and over 75% of the world's small plastic tunnels (Peet and Welles, 2005).

Because of seasonal climatic variations in agricultural areas, insect pests show varying trends in their incidence in nature. There some reports that the population of whitefly depends upon certain abiotic factors such as temperature, relative humidity, rainfall and sunshine hours (Janu and Dahiya, 2017; Jha and Kumar, 2017). Therefore, if the correlation of whitefly abundance and abiotic factors is understood, that knowledge can applied in designing a pest management program for tomato production in the green house.

OBJECTIVE

The objectives of this study were to compare the degree of white fly infestation in two varieties of tomatoes, and to investigate how whitefly population changed with meteorological parameters.

METHODOLOGY

The experiment was conducted in a greenhouse at the agricultural experimental area at Khon Kaen University. Seedlings (20 days old) of the tomato varieties Shiny Queen and Ninmanee were transplanted from nursery to the field. Meteorological data, temperature (ºC), relative humidity (%) wind speed (km/h), rainfall (mm), solar radiation (wat/m^2) and dew point (ºC) were recorded daily using a 2000 series Watch Dog weather station.

The population of whitefly was first observed when plants were 25 days old. The number of whiteflies was directly counted every other day between 16:00 and 17:00 from 23 tomato plants of each variety. Whiteflies were observed on three leaves (on upper, middle and lower parts of plant) using hand len of 10x magnification. Analysis of variance was conducted for testing the significance if one of the weather variables was linearly related to the whitefly population. The null hypothesis states that $\beta 1=\beta 2=\ldots\ldots\beta i = 0$. If alternative hypothesis is accepted ($\beta\neq 0$), then, a mathematical model of biting black flies can be analysed by logistic regression.

RESULTS AND DISCUSSION

Population dynamics of whiteflies from the two tomato varieties were similar during the vegetative and flowering stages. In the vegetative stage, the number of whitefly from both tomato varieties was lowest. Then, whitefly population gradually increased in the late flowering stage. Abundance increased by up to 18.3 and 2.39 insects/plant in Shiny Queen and Ninmanee, respectively. During fruiting and harvesting stage, the number of whitefly gradually increased in Shiny Queen variety, but it decreased in Ninmanee (Fig. 1). There were significant differences between the mean number of nymphs and adults of whitefly on the two tomato varieties. Shiny Queen was more infected with whitefly than was the Ninmanee variety (Table 1). The results of this study corresponded with the reports of Arnal et al (1998) and Patra et al. (2016) who found that whitefly were present throughout the growing period in tomato.

Abiotic parameters were separately analysed by logistic regression for each tomato variety (Table 3). The results revealed that the whitefly abundance on the Ninmanee variety was not related to abiotic parameters whereas it was on the Shiny Queen variety. This result may related to the small number of whitefly infections in the Ninmanee variety. When each abiotic parameter was separately analysed by logistic regression for the Shiny Queen variety, four of six parameters; temperature, relative humidity, solar radiation and dew point, were significantly related to the whitefly population with r^2 0.31-0.47 (Table 3). The results indicated that solar radiation and temperature were negatively related to the abundance of whitefly populations. These results were corroborated with the previous studies of Jha and Kumar (2017) who reported that sunshine hours was negatively correlated whitefly population on tomato. There was a positive relationship between whitefly abundance and dew point, and dew formation is a meteorological and hydrologic phenomenon which can provide an important water input. There is a report indicating that nutrients in dew can be assimilated by certain insect pests (Xu et al., 2015). The results differ from some previous studies where maximum temperature was found to be positively correlated with whitefly abundance (Bala et al., 2019).

Umar et al. (2003) have reported that the correlation of whitefly population abundance and temperature, relative humidity and precipitation was negative for whitefly populations on some varieties of cotton. However for certain other varieties, a positive correlation of abundance with temperature and relative humidity was observed. Janu and Dahiya (2017) found that weather parameters from different years show different levels of correlation. Therefore, the difference of host plant varieties or the duration of the experiment gave different results in respect to weather correlation. During this experiment, there was no rain and no wind speed because the experiment was done in a controlled greenhouse.

The regression equation of whitefly population with all weather parameters; temperature, relative humidity, wind speed, rainfall, solar radiation and dew point was analysed. Statistical analyses indicate that no weather variable was related to the number of whiteflies in the Ninmanee variety. However, there was statistically strong evidence that at least one of weather variables was related to the number of whiteflies in Shiny Queen. The regression model revealed a significantly positive association with only dew point, ($p < 0.05$), but not with any other of the weather variables ($p > 0.05$). The following regression model was selected as shown in Table 3 with $r^2 = 0.66$. This result differed from the previous report of Sharma et al. (2013) that six weather parameters played a significant role in whitefly abundance on tomato; maximum and minimum temperature, sunshine hours, maximum and minimum relative humidity, and rainfall. The differential results may depend on environmental conditions such as plant varieties, natural enemies, and cultural management.

Table 1 Mean number of nymphs and adults of whitefly on tomato varieties Shiny Queen and Ninmanee

Varieties*	Mean ± SD**		
	adult	nymph	nymph + adult
Shiny Queen	2.93 ± 3.01a	4.56 ± 5.6a	7.49 ± 8.03a
Ninmanee	0.95 ± 0.6b	0.50 ± 0.80b	1.46 ± 1.24b

* *n=23 (for each tomato varieties)*
** *Mean within a column followed by different small letters differ significantly ($p < 0.05$)*

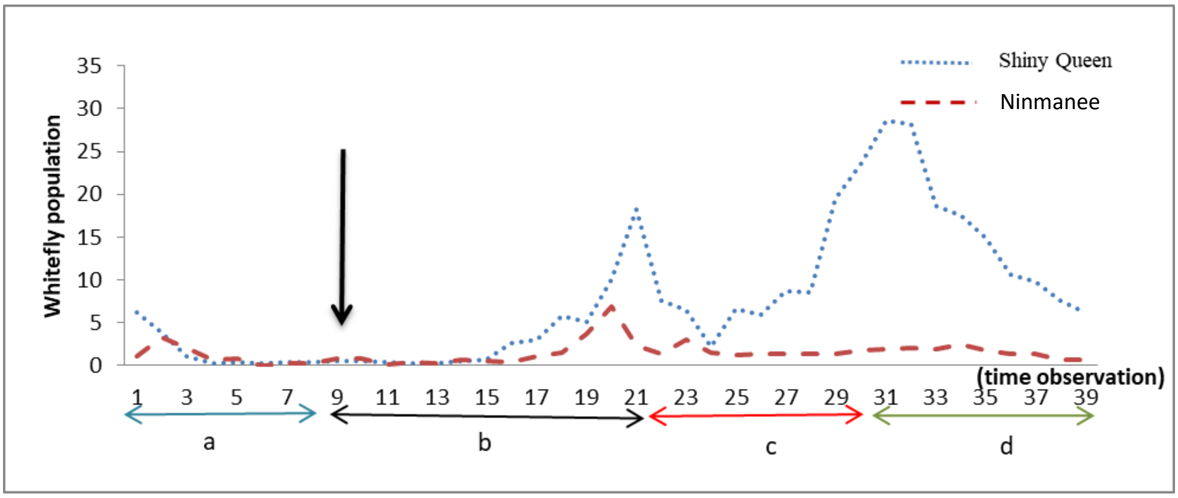

Fig. 1 Population dynamics of whitefly on tomato leaves during a= vegetative stage, b=flowering stage, c=fruiting stage, and d= havesting stage (arrow indicates insecticide application)

Table 2 Meteorological parameters data from tomato greenhouse during the experiment

Checked date	Temperature (°C)	RH (%)	Solar Rad (wat/m^2)	Dew Point (°C)	Rainfall (mm)	Wind Speed (km/h)
1	28.87	56.77	67.33	21.53	0	0
2	30.75	39.8	141	19	0	0
3	32.4	33.6	144.33	18.67	0	0
4	31.21	40.87	124.33	20.2	0	0
5	33.12	34.3	113.33	18.83	0	0
6	32.71	30.47	158.33	17.87	0	0
7	33.45	27.77	138	17.77	0	0
8	34.04	28.07	161.67	18.53	0	0
9	33.86	27.93	170.33	18.73	0	0
10	30.86	45.13	76.33	20.8	0	0
11	29.21	49.63	114.33	21.63	0	0
12	27.94	55.93	78	21.9	0	0
13	32.72	27.63	150	17.3	0	0
14	29.73	43.3	138	19.9	0	0
15	28.32	48.67	128.67	19.5	0	0
16	30.63	32.13	158.67	15.7	0	0
17	31.54	38.47	152.67	19.17	0	0
18	33.71	32.53	163	17.4	0	0
19	30.3	60.57	71	22.67	0	0
20	31.54	45.7	108.67	21.33	0	0
21	29.2	64.7	66.67	23.37	0	0
22	31.49	55.23	127.33	22.5	0	0
23	31.83	40.33	92.67	19.2	0	0
24	33.15	48.53	102.33	20.9	0	0
25	31.28	40.7	100.33	19.07	0	0
26	30.22	61.33	95	23.27	0	0
27	30.58	65.27	60.67	22.5	0	0
28	27.88	69.57	81.33	23	0	0
29	30.32	58.43	69.33	22.83	0	0
30	28.73	60.67	61	21.93	0	0
31	16.88	66.7	27.33	67.47	0	0
32	28.52	65.4	59.33	74.1	0	0
33	30.8	52.87	90.33	72.7	0	0
34	30.88	64.33	28	72.9	0	0
35	30.25	54	106	71.43	0	0
36	32.13	38.9	117	66.3	0	0
37	30.94	46.93	119.33	67.97	0	0
38	32.44	36.57	129.67	64.8	0	0
39	31.42	46.1	117.67	68.27	0	0

Table 3 Regression equations of weather variables related to whitefly population

	Shiny Queen		Ninmanee	
	Regression Equation	R^2	Regression Equation	R^2
Temperature (ºC)	$y = 56.54 - 1.59X$	0.31	-	-
Relative humidity (%)	$y = -12.2 + 0.42X$	0.44	-	-
Solar radiation (wat/m^2)	$y = 23.30 - 0.15X$	0.47	-	-
Dew point (ºC)	$y = 0.06 + 0.24X$	0.38	-	-
Wind speed (km/h)	-	-	-	-
Rainfall (mm)	-	-	-	-
Pooled weather parameters	$y = 15.36 + 0.16 dew\ point$	0.66	-	-

CONCLUSION

This experiment provided information on the population of whitefly infesting two varieties of tomato; Shiny Queen and Ninmanee. The statistical significance of whitefly numbers indicated that the Shiny Queen was more infested by whitefly than the Ninmanee variety. Some weather variables; temperature, relative humidity, solar radiation, and dew point, were related to whitefly population in Shiny Queen. Those parameters were used to create a mathematical model for white fly population in the greenhouse.

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