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Bionomics and population dynamics of *Bemisia tabaci* on subabul (*Leucaena leucocephala*)

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ABSTRACT

Leucaena leucocephala (subabul) has been recently reported as a host plant of the polyphagous whitefly *Bemisia tabaci*(Gennadius) from India. A study was carried out on the population dynamics of this whitefly on leucaena for two years and it revealed that its populations reached a peak (121.58 and 134.83 adults per two leaves) in September. The spatial distribution pattern revealed that it is always an aggregated dispersion (Taylor's Power Law) in all the strata but more aggregation in the middle leaves (b = 3.123). Linear association between population and weather factors revealed that maximum and minimum temperature had a significant positive correlation (r = 0.60, 0.54). The sex ratio in the field varied from 1:1.9 to 1:4.9 (male: female).The present observations indicate that incidence of *B. tabaci* on *L. leucocephala,* is an adaptation to a suitable host so as to survive during the winter season when the lowest temperature is about 2-4°C.

Key words : *B. tabaci, Leucaena leucocephala*, Population dynamics, Sex ratio, Spatial distribution, Weather factors

The *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) a devastating pest of agriculture, horticulture and forestry is polyphagous having more than 900 hosts (Global invasive species database, http:// www.issg.org/ database).The subabul (*Leucaena leucocephala*) has been recently reported as its new host from India (Thomas *et al*. 2011).Several studies had determined the spatial distribution of immature stages and adults of *B. tabaci* within plant in many important crops such as cotton (Naranjo and Flint 1994, 1995, Ahmad and Aslam 2002, Atakan and Canhilal 2004, Gencsoylu 2007, Karut and Kazak 2007), brinjal (Shen *et al*. 2005, Md. Rasdi *et al*. 2009) and tomato (Muniz *et al*. 2002, Arno *et al*. 2006, Gusmao *et al*. 2005, 2006). Its occurrence in high density on the leaves of leucaena prompted us to evaluate the population dynamics and explore the details of seasonal incidence, distribution pattern and sex ratio and correlate these with weather parameters at Delhi.The study was undertaken over a period of two years focusing on the adults.

MATERIALS AND METHODS

The field experiment was conducted at the Indian Agricultural Research Institute, New Delhi (28°4'N77°09'E and 228.16m) from September 2009 to August 2011. The populations were monitored at weekly intervals from six leaves that were randomly sampled per plant. From six leaves, two were taken from each of the plant strata namely upper, middle and lower, representing the distribution of leaves on plants. Adults were collected in aspirator and labeled with plant number and stratum. These were then brought to laboratory and counted. The adults were anesthetized with carbon dioxide for 15-20sec and sorted for sexes while they were inactive. These adults were further maintained at 30±2ºC and a photoperiod of 10:14 (L: D) for observation on the sex ratio of progeny through confining each female in a cage on a leaf. The effect of female age and multiple mating on sex ratio were evaluated in separate experiments as described by Horowitz and Gerling (1992). Data for weather parameters namely maximum and minimum temperature, relative humidity and rainfall were collected from the meteorological station, IARI Observatory, IARI, New Delhi.These data were utilized for computations of correlation and regression to evaluate the population dynamics.

Weekly means of incidence of whitefly on leucaena were determined and compared. The data were found normally distributed (Kolmogorov-Smirnov test) (SPSS) and the means and variances were $\log_{10} x$ transformed for normalizing before analyzing these for spatial distribution. The degree of whitefly

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aggregation was evaluated based on a simple empirical relationship as $\log s^2 = \log a + b \log x$ of Taylor's Power Law Linear Regression (Taylor 1961, 1984). The slope, b of this regression is a measure of aggregation, random and regular, and the y axis intercept, while a, is a sampling factor. The value of b, when significantly larger than 1 ($b>1$) would indicate aggregation; less than one ($b<1$), means that the dispersion is uniform,and the values that are not significantly different from 1 ($b=1$) show a random distribution. Differences in mean incidence were evaluated through ANOVA (one way).

RESULTS AND DISCUSSION

The mean incidence of whitefly populationsof all strata in 2009-10 is lower than that of 2010-11except from April to August (Fig 1). The incidence increased to a peak of (121.58 and 134.83 adults)inSeptember, thereafter it decreased gradually in December (19.47 and 20.87 adults). In the 2010-11 the population was higher than 2009-10 till March and later decreased gradually in August (56.66 to 12.33).In 2009-10 the incidence varied among the three strata, with the mean of 69.59, 79.54 and 63.85 adults for upper, middle and lower strata, respectively (Fig 2a). In 2010-11 these means reduced to a level of 56.32, 68.94 and 52.68 adults, respectively (Fig 2b). The mean incidence was statisticallyinsignificant for both stratum and year of observation.

In 2009-10 the incidence increased to a peak of 126.25, 152.12 and 86.5 adults in September for upper, middle and lower strata, respectively (Fig 2a). In 2010-11 these increased to 126.25, 179.25 and 99.12 adults, respectively (Fig 2b). However, it gradually decreased towards December to 21.21, 18.2 and 19.2 adults in 2009-10 and 24.2, 19.6 and 18.8 adults in 2010-11, for upper, middle and lower strata, respectively. In 2009-10 the population fluctuated and increased to 94.8 and 89.25 adults in April for upper and middle strata and 79.75 adults in February for the lower stratum (Fig 2a). In 2010-11, it increased to 91.25 and 85.5 adults in February for upper and lower strata and 133.25 adults in March for middle stratum (Fig 2b).Then it gradually decreased towards the end of the year for all the strata. The number of adults varied on strata of plant, ranging from 18.2 to 152.12 adults in 2009-10 and from 9.9 to179.25 adults in 2010-11 and it was statistically insignificant.

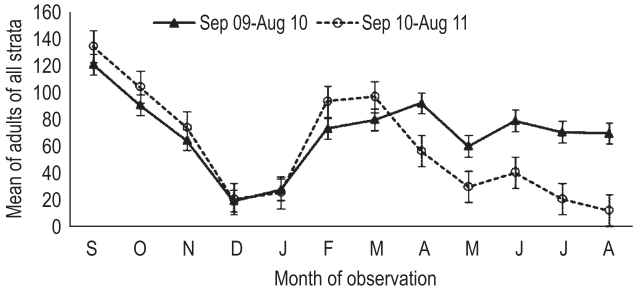


Fig 1 Distribution and abundance of adults in three strata (Sept 2009- Aug 10 and Sept 2010- Aug 2011).

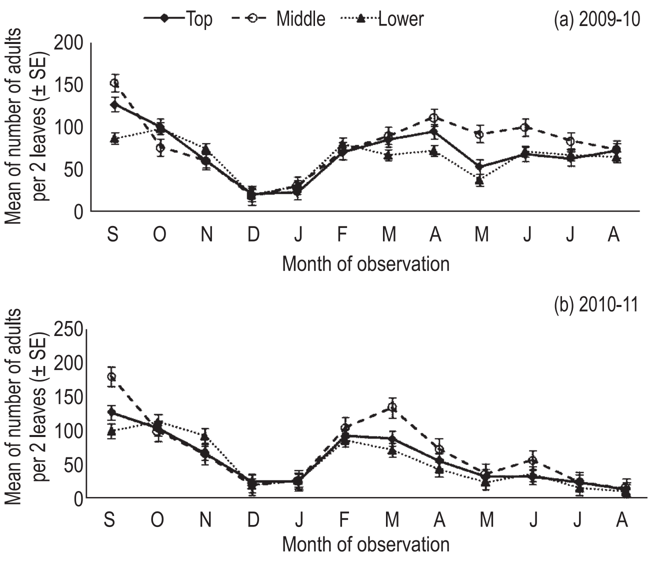


Fig 2 Mean number of adults on upper, middle and lower strata; (a) 2009 -10; (b 2010 -11.

The spatial distribution of adults was found to be aggregated (Fig 3). In 2009-10, the dispersion patterns in upperand lower strata were significantly different compared to that of the middlestrata; the middle ($b=3.123$) stratum showed a more obvious aggregated pattern (Fig 3a) whereas in 2010-11, thelower($b= 2.53$) stratum showed more aggregation than upper and middle strata (Fig 3b).

As regards the relationships with weather factors, the populations peaked during September with maximum temperature of (34.1-31.25°C), minimum temperature of (23.25-24.3°C), maximum and minimum % relative humidity of (87-96.25% and 62.25-67.5%) and 19.85-2.35 mm of maximum and minimum rainfall,respectively. Analysis of the linear association between population and weather parameters revealed that temperature maximum and minimum in 2009-10 ($r= 0.57, 0.60$) and temperature minimum in 2010-11 ($r= 0.54$) had a significant positive correlation.However % relative humidity and rainfall did not have any influence on the populations (Table 1).

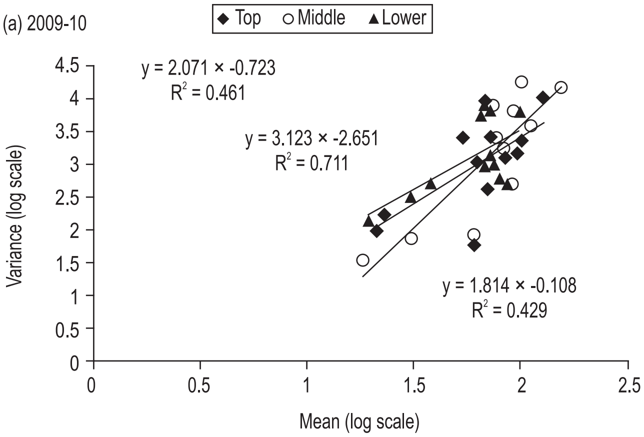
The sex ratio varied from 1:1.9 to 1:4.5 in 2009-10 and 1:1.9 to 1:4.9 in 2010-11, although with slight differences in each month.The sex ratio increased to a peak of (1:4.5 and 1:4.9) in September, thereafter it decreased (1:1.9) in October for 2009-10 while it was in October and July respectively for 2010-11.Regression analyses that express the percentage of females among the year showed that there are no statistically significant differences between the years. Laboratory experiments showed that the multiple matings did not change the total number of eggs laid per female (mean, 65.1 versus 72.9; $P>0.05$), but longevity was significantly higher for the

Table 1 Quantitative analysis of seasonal incidence of adults in relation to weather.

Weather factors	2009-10			2010-11		
	r	Regression equation	R^2	r	Regression equation	R^2
Temperature maximum	0.57*	Y= 0.172x+19.39	0.33	0.45	Y= 0.092x+23.52	0.20
Temperature minimum	0.60*	Y= 0.183x+4.59	0.36	0.54*	Y= 0.132x+7.165	0.29
Relative humidity maximum	–0.18	Y= –0.107x+86.76	0.03	0.03	Y= 0.010x+83.33	0.00
Relative humidity minimum	–0.15	Y= –0.087x+50.78	0.02	0.02	Y= 0.112x+40.14	0.06
Rainfall	0.42	Y= 0.0119x–4.336	0.18	0.47	Y= 0.014x–0.584	0.22

r= Correlation coefficient, * Correlation significant at P=0.05 (2 tailed).

(a) 2009-10



(b) 2010-11

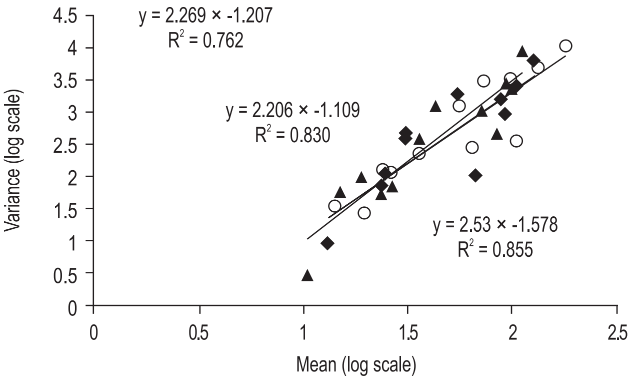


Fig 3 Spatial distribution of adults (Taylor's Power Law regressions); (a) 2009-10; (b) 2010-11.

female that mated only once (9.5 versus 13.4; P<0.05). Multiple matings significantly increased the ratio of female progeny (P<0.05). In both single and multiple matings, overall sex ratio was higher during the first half of the female's life. This was especially prominent in the multiple mated female, where the sex ratio was above 1:1 for the first 6 days, which then declined sharply.

The spatial distribution of *B. tabaci* on leucaena was found aggregated in all strata with aggregation being more in the middle stratum. Such a distribution pattern agrees well with the ones described for *B. tabaci* adults on tomato and pepper (Muniz *et al.* 2002) and immatures on peanut (Lynchand Simmons 1993) and brinjal (Md. Rasdi *et al.* 2009). But it is not in agreement with those obtained on cotton (Butler and Vir 1990, Rao *et al.* 1991, Naranjo and Flint 1995, Li *et al.* 2010), where in adults were observed to be most abundant on younger leaves near top of the plant.

As observed by Gerling *et al.* (1986), the field observations do not conform with laboratory observation as regards sex ratios. Most notably two patterns had been reported; a uniform, female biased sex ratio with year round populations on *Lantana camera* in Egypt (Azab*et al.* 1971) and variable ratios that changed between male and female predominance (Horowitz and Gerling 1992).The current observations indicate that the field populations of *B. tabaci* on *L.leucocephala* have a female biased sex ratio throughout. The laboratory experiments showed that the sex ratio of progeny changes with the age of the mothers, producing a greater proportion of male as they get older, similar to the results of Horowitz and Gerling (1992). Changes in the sex ratio may also result from differential survival of the sexes, but multiple matings were required to sustain female progeny (Liu *et al.* 2007). In *B. tabaci,* where females live about three times as long as males (Avidov 1956, Azab *et al.* 1971), one would expect a female-biased sex ratio, especially if the females are able to survive to the full extent of their life expectancy.

Climatic factors such as temperature, wind, rain, and relative humidity, as well as natural enemies, play important roles in the population dynamics of whiteflies (Horowitz *et al.* 1984, Lu *et al.* 2012). The present results show that the temperature had a significant positive correlation while humidity and rainfall did not have any influence which is similar to the result of Leite *et al.* (2005) for temperature but differs in the effect of rainfall.These suggest that climatic factors are not the major factors for seasonal incidence of *B. tabaci* populationsas had been shown earlier (Hirano *et al.* 1995, Naranjo and Ellsworth 2005). In general *B. tabaci* is defined as a thermophilic insect. It can infest plants throughout the year in tropical areas, but must move to a suitable environment with host plant to overwinter in subtropical and fringe temperature zones (Avidov 1956, Lin *et al.* 2007). It was reported that 19 plant species in greenhouses, including vegetables, ornamentals plants and weeds were the main hosts of *B. tabaci* during the winter (Gerling 1984, Lin *et al.* 2007). The present observations indicate that incidence of *B. tabaci* on *L. leucocephala,*is an adaptation to a suitable host so as to survive during the winter season when the lowest temperature is about 2-4°C.

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