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Studies on Seasonal Abundance and Insecticidal Management of Whitefly (*Bemisia tabaci* Gennadius) in Brinjal

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ABSTRACT

Whitefly (*Bemisia tabaci* Gennadius), the tiny white colored soft bodied phloem feeder now been acclaimed as international threat to several agricultural crops due it's high polyphagous nature. Field experiment as well as lab experiment have been conducted during 2017 and 2018 to cram seasonal abundance of whitefly and bioassay of insecticides to assess the efficacy against whitefly. It was recorded that the population of whitefly in the experimental years are considered as minor as the population level was below the economic threshold level. Maximum temperature, minimum temperature and rainfall recorded due course of time showed negative correlation with the whitefly population, while relative humidity was positively correlated with the population. The most favourable temperature for population build up was ranged in respect of minimum temperature and maximum temperature was 12-30^{0}C depending on the favourable vegetative stage of the crop. It was apparent that the efficacy of insecticides under leaf dip assay ascertained after 24 and 48 h of exposure that flonicamid exerted maximum potency (84.95%) against whitefly followed by alphamethrin (75.47%), spiromesifen (75.23%). Lowest potency was recorded by bupropezin (55.79%).

INTRODUCTION

Vegetables serve as an important source of vitamins, minerals and plant proteins in human diets throughout the world. *Solanum melongena* L. or aubergine is a species of nightshade is one of the most important vegetables. At the same time a series of insect pest have been reported to interacting with it and due to their infestation the production of the crop get reduced than the potential yield. The losses caused by brinjal pests vary from season to season depending upon environmental factors (Gangwar and Sachen, 1981). Due to intensive agriculture and climate change in present scenario several minor pests are becoming predominated while some major pests become minor. The interaction between pest activity and abiotic factors helps in deriving at predictive models that aids in forecast of pest incidence (Ghosal, 2019). Among the insect pests infesting brinjal, the major ones are shoot and fruit borer, *Leucinodes orbonalis* (Guen.), whitefly, *Bemicia tabaci* (Genn.), leafhopper, *Amrasca biguttula biguttula* (Ishida), Epilachna (Singh and Singh, 2002). Different biotic and abiotic factors widely influence the plant growth, thereby subsequently interfere with the pest biology. Hendrix *et al*. (1992) reported that whitefly (*Bemisia tabaci* Gennadius), placed in the family aleyrodidae is now becoming important ones along with the rapid spread of *B. tabaci*, new biotypes appeared. The taxonomic status of *B. tabaci* remains debated between 20 previously identified biotypes (Perring, 2001), of which biotype B and Q were most common and invasive. Ghosal *et al*. (2021) reported the presence of "Q" biotype of *B. tabaci* which showed varied level of resistance against insecticides in West Bengal condition. Present agriculture mainly focuses on the management of pests rather to control them to conserve the agricultural ecosystem. It has been reported that *B. tabaci* Gennadius, has developed a high degree of resistance and resurgence against several chemical classes of insecticides (Elbert and Nauen, 2000; Ghosal and Chatterjee, 2018). This has prompted the necessity of assaying different new molecules in changing climate. In

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the present study whitefly population abundance in brinjal was ascertained along with the bioassay study of some varied insecticide chemistry for effective management.

MATERIALS AND METHODS

Field experiments were conducted in the instructional farm of Sasya Shaymala Krishi Vigyan Kendra situated at Arapanch, Sonarpur, West Bengal, located at 22º4 N latitude, 88.2ºE longitude and at instructional farm of IRDM Faculty Centre, Ramakrishna Mission Vivekananda Educational and Research Institute, Ramakrishna Mission Ashrama at Narendrapur, located at 22.4° N longitude and 88.4°E latitude. The experiments were conducted during *rabi* season of 2017 and 2018. Brinjal (var. *Boral*) was raised with recommended package of practices in (3 x 3) m^2 plots at a spacing of 50 cm X 50 cm. To evaluate the effect of abiotic factors on the whitefly population, brinjal seedlings were planted in three different planting at monthly interval starting from 23rd October, 23rd November and 23rd December. The experiments were laid out in Randomized Block Design (RBD) with 6 insecticidal treatments along with a untreated control replicated thrice and randomized. Except the experimental schedule no plant protection intervention were followed. Similar agronomic practices were followed in all the treatments to eradicate the influence of agronomic intervention.

Study of population abundance of whitefly

Adult whitefly population was recorded from three leaves per plant (ten plants per plot) from each plot at weekly interval starting from one month after transplanting and continued up to 112 days (16 week) from the date of first count at three planting dates at early morning (7.00 h). The mean maximum and minimum temperature, relative humidity and average rainfall (the meteorological data) was recorded during the entire period of study from the Agro-meteorological station at Kakdwip, South 24 Parganas. The inter-relationship between the population and meteorological data has been worked out through correlation, regression and multiple regressions. Simple and multiple regression analysis between pest population and weather conditions (X_1, X_2, X_3, X_4, X_5, X_6) were worked out and the data were processed on spectrum of computer regression as $Y = a+b_1X_1+ b_2X_2 + b_3X_3+ b_4X_4+ b_5X_5+ b_6X_6$. Where, $b_1 \ldots b_6$ are regression coefficient of $X_1 \ldots X_6$.

Bioassay study of insecticide

Bioassay studies were conducted with six promising insecticides viz. dinotefuran 20 SG (0.3 gm/ltr), alphamethrin 10 EC (1 ml/ltr), buprofezin 25% SC (1.6 l/trl), spiromesifen 24 SC (1 ml/ltr), flonicamide 50 SG (2 g/ltr), chlothianidin 50 WDG (0.2 g/ltr) with recommended doses along with a separate untreated check (water was sprayed) in Randomized Block Design (RBD). Leaf dip bioassay method was followed as suggested by IRAC. The tender succulent green leaves of brinjal were dipped into the test solution of insecticide for 10 seconds with gentle agitation. Leaves were carefully be drained of excess liquid and air dried for 1 h before being placed in petridis (Liu and Stansly, 1995). Adult whiteflies (10 numbers) collected from the field were aspirated for each treatment. Mortality was assessed after 24 h and 48 h, respectively. Percent mortality was recorded in microsoft excel and subjected to convert in corrected percentage mortality illustrated by Henderson and Tilton's (1955) and data was analyzed to compare mean subjected to analyze in Duncan's new multiple range test (DMRT) using SPPS 23 software.

$$\text{Corrected \%} = 1 - \frac{\text{n in Co before treatment} \times \text{n in T after treatment}}{\text{n in Co after treatment} \times \text{n in T before treatment}}$$

(n= Insect population; T= treated; Co= control)

RESULTS AND DISCUSSION

Intensity of whitefly infestation in relation to meteorological factors in different dates of planting of brinjal

Population abundance of a pest is directly related with the weather factors as well as the growth stage of the plant. Effective management strategy as well as pest forecasting relies upon the biology of the pest and their population fluctuation in respect of abiotic factors *viz.* temperature (°C) (maximum and minimum), relative humidity and total rainfall. The present findings showed discrete population fluctuation of whitefly depending on the weather parameters and different growth stages of the crop in all the three planting times.

Population dynamics of whitefly in October transplanted brinjal

B. tabaci population varied to the tune of 0.3 to 2.6 per leaves during the growing period. During our first observation taken on 47th standard week of 2015, only 0.3 numbers (nos.) of individuals was recorded per leaves was noted. Depending on favorable climatic condition and favorable growth stages of the crop, the population started to increase and the first peak population was observed during 49th standard week of 2017, when the max. temperature was 27.0 °C and min. temperature was 17.86°C, relative humidity was 89.57 %, with no rainfall. With a rainfall of 10.67 mm in the next week the population of whitefly dwindled off to 0.3 individuals per leaf. With the favorable weather condition the population again started to increase and reached its second peak during 1st standard week of 2018, when the max. temperature was 24.5°C and min. temperature was 12.86°C, relative humidity was 89.86 %, with no rainfall. No critical fluctuation in population abundance was observed between 1st standard week to 7th standard week. With the sudden increase of max. temperature (31.1°C) on 8th standard week the population gets reduced to its lowest (0.3 individuals per leaves). In the very next week the population again recovered to 1.66 individuals per leaf, the max. temperature was 29.0°C and min. temperature was 20.4°C, relative humidity was 92.3 %, slight rainfall of 4.4 mm during this course of time favors the growth and development of the population. During the last count taken on 11th standard week the population was recorded to 0.6 individuals per leaf (Fig. 1A).

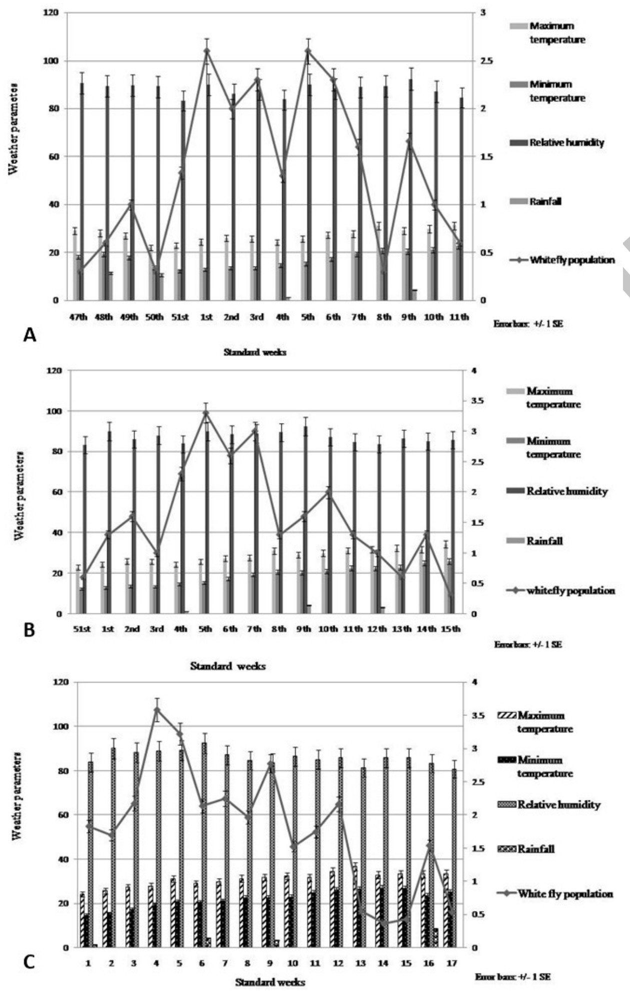

Fig. 1. Seasonal incidence of whitefly in October planted (A), November planted (B) and December planted (C) Brinjal (Pooled).

Population dynamics of whitefly in November transplanted brinjal

During the first count taken on 51st standard week 0.6 individuals per leaf was recorded. The population was slowly went up and attained first peak (1.6 per leaf) on 2nd standard week. The population was started to increase with the favourable weather condition and reached its highest peak (3.3 nos. of individual per leaf) during 5th standard week; the max. temperature was 25.7°C, and min. temperature was 15.4°C, relative humidity 90.0% and no rainfall was recorded in this period. During the last count taken on 15th standard week only 0.3 individual per leaf was recorded. It is prominent that the population was also influenced by the age of the crop (Fig. 1B).

Population dynamics of whitefly in December transplanted brinjal

It is obvious that unlike other two transplanting dates the count taken during first that is on 4th meteorological week (fourth week of January) the population of whitefly was 1.8 individuals per leaves at 28 days of crop age and after subsequent count taken after it was noticed that population was gradually started to increase (Fig. 1C). During 7th standard meteorological week the population attained highest peak (3.6 whiteflies per leaf) during second week of February' 2018 while, the temperature was ranged from 19.4 -27.8 °C, relative humidity 88.9 % and zero rainfall. The population of whitefly showed its second peak during 12th standard week. Afterwards with the increase of temperature, the population dwindled off to 1.5 whiteflies per leaf on 13th meteorological week. The population of whitefly had a tendency to decrease during 2nd week of April (16th standard week) and It was noticed that the population was strongly affected with high temperature above 35°C. Within our observation period the last peak was noticed during 19th standard week.

It is prominent from the present observation that in all the three planting dates though the population get influenced by the abiotic factors but the population was under economic threshold level. The impact of environmental factors on the population build up of whitefly on brinjal was evaluated through correlation coefficient (r) analysis between the pest population and environmental factors as well as through multiple regression factors (R^2) and regression equation was also established. The data pertaining to correlation coefficient (r) between population of whitefly and weather factors have been depicted in Tables I and II. The interaction showed negative trend with temperature and rainfall; whereas during this phase of crop growth population showed positive interaction with relative humidity and low rainfall. During December planting the minimum temperature (0.53) and relative humidity (0.51) showed significant relation with the population dynamics of whitefly. Multiple regression factors (R^2) shows not so good impact during the growth phase under the three planting time. In all the case the interaction is only 47, 46 and 40 per cent for October, November and December planting, respectively. From the present findings it is prominent that population buildup of whiteflies were not in great extend; there may be several factors affecting the population buildup. It can be assumed that varietal characters may exert detrimental effect on the population buildup also.

Table I. Pearson correlation coefficients between incidence of whitefly and weather parameters.

Meteorological parameters	(X)	October	November	December
Maximum temperature	(X_1)	-0.34	-0.378	-0.468
Minimum temperature	(X_2)	-0.48	-0.274	-0.53*
Relative humidity	(X_3)	0.05	0.411	0.51*
Rainfall	(X_4)	-0.39	-0.044	0.08

* Correlation is significant at the 0.05 level (2-tailed).

Table II. Regression equations showing quantitative relationship between *B. tabaci* (Y) and meteorological parameter (X).

Planting time	R^2	Regression equation
October	0.471	$Y = -4.549 -.035 (X_1) - 0.110(X_2) + 0.101 (X_3) - 0.108 (X_4)$
November	0.467	$Y = -3.529 -.485 (X_1) + 0.316(X_2) + 0.150 (X_3) - 0.095 (X_4)$
December	0.402	$Y = -8.699 + 0.148 (X_1) - 0.201(X_2) + 0.120 (X_3) + 0.023 (X_4)$

X_1, Max. temperature; X_2, Min. temperature; X_3, Relative humidity and X_4, Rainfall.

It is evident from field experiments that whitefly population was not get potentially influenced by the weather parameters in different dates of planting during experimentation. In our experiment it is prominent that the population of whitefly was relatively higher in December planted brinjal as during the vegetative growth period the abiotic factors was favourable for population buildup of whiteflies. The most favourable temperature is below 30°C with low humidity depending on the favourable growth stage of the crop. Dry period greatly favoured the population build up; whereas low temperature also affect the population buildup. Our result is in confirmation with the findings of Chaudhuri *et al*. (2001). Banjo and Banjo (2003) reported the same result that during dry period of December and January optimum population of spiraling whiteflies were recorded in Nigeria. The simple correlation matrix of whitefly population and weather factors showed few sort of inconsistency based on the weather parameters recorded on that growing period of the crop. Whitefly population was negatively correlated with maximum temperature, minimum temperature and rainfall; which is in conformity of the findings of Ghosal (2022) and Sitaramaraju *et al*. (2010). On the other hand relative humidity was positively correlated with the whitefly population. Similar result was reported by Ghosal (2022), who reported that during November planted cotton and tomato both maximum and minimum relative humidity was positively correlated with the population dynamics of whitefly. Meena *et al*. (2010) opined that abiotic stress (maximum and minimum temperature, relative humidity and rainfall) had non-significant correlation coefficient with the population of whitefly.

Bioassay of insecticides against whitefly in brinjal

Significant reduction of whitefly population was recorded in all the treatments within 24 h of application (Table III). In respect of individual count taken on 24 h of inoculation flonicamid was considered as best insecticide (2.33 nos.) providing 74.07% mortality, which was significantly superior over other insecticidal treatment also. Spiromesifen (3.33 nos. with 62.96% mortality), clothianidin (3.33 nos. with 62.96% mortality), alphamethrin (3.67 nos. with 59.26% mortality) and dinotefuran (3.67 nos. with 59.26% mortality) was statistically at par with each other in respect of mortality of aspirated whiteflies. Though all the insecticidal treatments were statistically at par with each other during 48 h after imposing the treatments; flonicamid recorded 95.83% mortality and considered as best insecticide against whitefly. The mean value of population mortality showed that flonicamid recorded highest (84.95%), whereas lowest was achieved by buprofezin (55.79%).

The experimental result shows that flonoicamid was the best treatment against whitefly which can be compared by the findings reported by Ghosal *et al*. (2018) and Black and Gravelle (2008), who reported that flonicamid (pyridincarboxamids derivates) has an important feature against plant suckers due to its ability to seize feeding (Hayashi *et al*., 2008). In our present findings the synthetic pyrethroids alphamethrin was considered as the second best insecticide against field collected whitefly population. Being broad spectrum insecticide this is highly economical insecticide remains effective for longer duration and therefore gives protection for a longer time. We also found that spiromesifen (lipid bio-synthesis inhibitor)

Table III. Mortality of whitefly against different treatment following leaf dip assay (Pooled).

S No.	Treatments	Pre treatments	24 h population	Corrected mortality (%)	48 h population	Corrected mortality (%)	Mean corrected mortality (%)
1	Alphamethrin	10.00 (3.16±00)	3.67 (1.82±0.41)[bc]	59.26	0.67 (1.00±00)[b]	91.67	75.47
2	Spiromesifen	10.00 (3.16±00)	3.33 (1.82±0.09)[bc]	62.96	1.00 (1.00±00)[b]	87.50	75.23
3	Clothianidin	10.00 (3.16±00)	3.33 (1.82±0.09)[bc]	62.96	1.33 (1.14±0.14)[b]	83.33	73.15
4	Flonicamid	10.00 (3.16±00)	2.33 (1.52±0.11)[c]	74.07	0.33 (0.33±0.33)[b]	95.83	84.95
5	Dinotefuran	10.00 (3.16±00)	3.67 (1.91±0.09)[bc]	59.26	1.00 (1.00±00)[b]	87.50	73.38
6	Buprofezin	10.00 (3.16±00)	5.33 (2.28±0.28)[b]	40.74	2.33 (1.24±0.63)[b]	70.83	55.79
7	Control	10.00 (3.16±00)	9.00 (2.99±0.17)[a]	00	8.00 (2.82±0.18)[a]	00	00

showed wide potency over whitefly population. Nauen and Konanz (2005) and Natwick and Lopez (2006) confirms our present findings. The lower efficacy of buprofezin in the present is can be assumed that being an insect growth regulator the effect of buprofezin was not prominent within 48 h as it is effective against growth and development of the immature, but from the result it is clear that the percent mortality of buprofezin was increased in 48 h, which indicated its potentiality over whitefly. Ali *et al*. (2005) reported that buprofezin was proved to be effective against whitefly nymphs on cotton which is in conformity with our present study. Neonicotinoids, which act as competitive inhibitor of nicotinic acetylcholine receptors in the central nervous system, is a potent insecticide against sucking pest including whitefly. Their systemic property and long residual activity make them ideal insecticides against sucking pests was reported by Ghosal *et al*. (2021). The experimental result showed that clothianidin at its recommended dose furnished good protection against whitefly. Similar result were reported by Ghosal and Chatterjee (2018), Deosarkar *et al*. (2011) and Laurino *et al*. (2013). The newly classified Q biotype was virtually showed resistance to pyriproxyfen and synergized pyrethroids and striking reduced in susceptibility to buprofezin, imidacloprid, acetamiprid and thiamethoxam as reported by Dennehy *et al*. (2005).

CONCLUSION

There are several factors interacting with the biota and influence their population build up, one of the important factors are the abiotic factors, from the present study it is quite prominent that the population of whitefly get influenced by the weather factors as well as by the growth stage of the crop and the population was under economic threshold level. Population of whiteflies in the local brinjal cultivar was negatively correlated with the temperature and rainfall; though low rainfall influence the buildup of population. Relative humidity on the other hand were positively correlated with population of whiteflies. Flonicamid the stylet feeding blocker showed good potency that may be incorporated in the comprehensive integrated pest management strategies.

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Ethical statement

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Statement of conflict of interests

The authors have declared no conflict of interests.

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