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Population dynamics of whitefly (*Bemisia tabaci* Genn.) infesting tomato (*Lycopersicon esculentus* L.) and their sustainable management using bio-pesticides

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Abstract
The present research was undertaken to study the population dynamics of whitefly (*Bemisia tabaci* Genn.) infesting tomato (*Lycopersicon esculentus* L.) and their sustainable management using bio-pesticides. The maximum population level was maintained during 11th standard week to 18th standard week that is during 2nd week of March to 3rd week of March with peak population (0.47/leaf) was recorded. Weekly population counts on white fly showed non-significant negative correlation (p=0.05) with temperature and weekly total rainfall where as significant negative correlation with relative humidity. The insecticide acetamiprid was found most lethal against whitefly providing 76.59% suppression, closely followed by extracts of neem + *Spilanthes* providing 62.39% suppression. Neem and *Spilanthes* individually did not produce good results but when used as a mixture they recorded better results. Highest yield (30.15 t/ha) were recorded from acetamiprid treated plots followed by neem + *Spilanthes* (27.55 t/ha). Azadirachtin and Plant extracts are biopesticides having less or no hazardous effects on human health and environment. Thus they can be incorporated in IPM programmes and organic farming in vegetable cultivation.

Keywords: Seasonal fluctuation, bio-pesticides, vegetable IPM, organic farming

1. Introduction

Tomato is an important vegetable crop for small scale and the most promising areas for horticulture development [6]. *Bemisia tabaci* (Genn.) is an important plant pest world-wide [10]. In the sub-Himalayan region of north east India tomato is cultivated at a commercial scale but one of the limiting factors affecting the successful cultivation of this crop is the existence of whiteflies [4]. Damage caused by this insect pest to commercial tomato may be directly through phloem feeding, or indirectly by the transmission of plant viruses such as *Tomato Yellow Leaf Curl Virus* (TYLCV) [8]. In spite of a variety of control measures applied against pests, crop losses have consistently shown an increasing trend [5]. High infestation levels were found from mid-February to mid-March [4, 10] observed the insect vectors Whitefly (*Bemisia tabaci* Genn.) attack tomato plants during April-November (Maximum damage during Aug-Oct) causing heavy losses [2]. Reported that the incidence of white fly population had a significant and positive correlation with temperature and sunshine hours while a negative correlation with relative humidity and total rainfall. The disease incidence had a significant and positive correlation with white fly population [12].

The organochlorine and organophosphorus compounds have been reported to pose a potential threat to all types of ecosystem [11]. Different groups of insecticides have been recommended to control this white fly [14, 15]. Previous research has evaluated less toxic and more environmentally safe insecticides to control *B. tabaci*. For example [9], reported that the botanical insecticides Neemax (neem seed kernel extract) and Multineem (neem oil) regulated populations of this white fly. Additionally, the oil of *Pongamia* repelled brown plant hopper (*Nilaparvata lugens* Stall) in rice and significantly reduced its ingestion and assimilation of food. Both brown plant hopper and white backed plant hopper suffered heavy mortality [7]. *Polygonum* is a well-known weed in the terai agro-climatic region of West Bengal, India locally known as "Biskanthali" [13, 3] reported from Pakistan that crude leaf and flower extracts of *Polygonum hydropiper* were responsible for mortality rates 10 days after feeding of 28% and 52% for *Heterotermes indicola* and 28% and 74.7% for *Coptotermes heimi* respectively.

The objective of the study was to search peak period of the whitefly incidence to make a decision for taking plant protection measure and formulate suitable control measure with the use of bio-pesticides to reduce the health hazards and environmental pollution.

2. Material and Methods

2.1. Study period and location

The present study was conducted in the Instructional Farm of Uttar Banga Krishi Viswavidyalaya at Pundibari, Coochbehar, West Bengal, India for two consecutive years (2011-13) in the rabi season. The experimental area is situated in the sub-Himalayan region of north-east India. This so called terai zone is situated between $25^0$57' and 27^0 N latitude and $88^0$25' and $89^0$54' E longitude. The soil of the experimental field was sandy loam with pH value 6.9. The climate of this zone is subtropical humid with a short winter spell during December to February.

2.2. Seasonal incidence of white fly

To study the population fluctuation and seasonal incidence of whitefly as well as the influence of prevailing weather conditions on the population dynamics, the tomato variety 'Pusa ruby' was grown round the year except rainy season when tomato cultivation is not possible in open field in this area, during 2011-2013 in both years under recommended fertilizer levels (120:60:60 kg NPK/ha) and cultural practices in 4.8 m x 4.5m plots at a spacing of 75 cm x 50 cm. The treatments were replicated five times in a Randomized Block Design (RBD). The total white fly population per leaf from top, middle and bottom leaves from five randomly selected plants per replication was recorded at seven days (Standard Meteorological Week) interval during tomato growing seasons in both the years. Data obtained over two years were presented graphically with important weather parameters viz. temperature, relative humidity. Correlation co-efficient (r) was worked out between incidence of mite and important weather parameters during the period to find out influence of weather on population fluctuation.

2.3. Evaluation of plant extracts and neem pesticide against whitefly

2.3.1. Cultivation practices

This two year (2011-2013) study was conducted at the instructional farm of Uttar Banga Krishi Viswavidyalaya (State Agricultural University) at Pundibari, Coochbehar, West Bengal, India. The tomato variety 'Pusa ruby' was grown during the rabi season (January-Feb.) in both years under recommended fertilizer levels (120:60:60 kg NPK/ha) and cultural practices in 4 m x 5m plots at a spacing of 75 cm x 50 cm. The treatments were replicated three times in a Randomized Block Design (RBD).

2.3.2. Treatments

One botanical insecticide azadirachtin i.e. neem (neemactin 0.15 EC) @ 2.5 ml/L, and four botanical extracts viz. tobacco *(Nicitiana tabacum)* leaf extract @ 7.5% (75ml/L), *Polygonum hydropiper* floral part extract @ 5.0% (50ml/L), *Spilanthes paniculata* floral parts extract @ 5.0% (50ml/L), and garlic (*Allium sativum*) extract @5.0% (50ml/L), and one treatment containing mixture of neem (neemactin 0.15 EC) and floral extract of *Spilanthes* 4.0% (@ 1.5 ml and 40 ml/L were evaluated against white fly. These were compared with the ability of acetamiprid (Pride 75 SP), a chemical insecticide @ 1g / 3L to control the whitefly on tomato along with no treatment (control) where no insecticide was used.

2.3.3. Preparation of Extracts

Polygonum hydropiper is also well known as a weed in this terai agro-climatic region of West Bengal, India. *Spilanthes paniculata* is also well known as a weed in this terai agro-climatic region of West Bengal, India. Garlic (*Allium sativum*) is available in india and used as spices for preparation of delicious food. The *Polygonum hydropiper* plants floral parts, *Spilanthes* floral part and garlic edible part were extracted in methanol as follows. After washing with water, the plant parts were powdered in a grinder. The powder (50 g) samples of each tested plant were transferred separately to a conical flask (500 ml) and dipped in 250 ml methanol. The material was allowed to stand for 72 hours at room temperature with occasional stirring. After 72 hours the extract was filtered through Whatman 42 filter paper and residues were washed twice with methanol. Tobacco (*Nicotiana tabacum)* is cultivated in a large scale in the locality where experiment has been done. The tobacco leaves were extracted in water as follows. After washing with water the leaves were dried and powdered in a grinder. The powdered sample (100 g) were transferred to a container and dipped in 1 litre water. The material was boiled for about half an hour and then allowed to stand for 72 hours at room temperature with occasional stirring. After 72 hours the extract was filtered through Whatman 42 filter paper and added 15 ml liquid soap.

2.3.4. Data recording

Four sprays at 12 day intervals were made, starting with the initiation of infestation. White fly population densities were recorded 3, 7, and 11 days after each spraying. The total white fly population per leaf from top, middle and bottom leaves from five randomly selected plants per replication was recorded. The results were expressed as white fly population suppression (%) compared to densities recorded on the control treatment. Percent reduction of white fly population over control was calculated by the following formula [1]:

$$Pt = \frac{Po - Pc}{100 - Pc} \times 100$$

Where, Pt = Corrected mortality, Po = Observed mortality and Pc = Control mortality.

The tomato fruits were harvested at frequent intervals when they attained marketable size. The yield of marketable produce was calculated in different years separately on the basis of fruit yield per plot and converted to tons per hectare.

2.3.5. Statistical analysis

Data were analyzed by using INDO-STAT- software for analysis of variance following randomized block design (RBD) treatment means were separated by applying CD Test (critical difference) at 5% level of significance.

3. Results and Discussion

The pooled data on whitefly incidence for the two years (2011-12 and 2013-14) showed that whitefly was active all throughout the year (Fig. 1). Lower population level was recorded during 38th standard week to 41st standard week that is during 3rd week of September to 2nd week of October when the average temperature, relative humidity and weekly total rainfall were 27.42 ºC-28.80 ºC, 75.59%-92.46% and 8.80mm-240.00mm. Higher population level was maintained during 11th standard week to 18th standard week that is during 2nd week of March to 3rd week of March with peak population

(0.47/leaf) was recorded. In the terai region of West Bengal (Sub-Himalayan of N-E India) high infestation levels were found from mid-February to mid-March [4]. This findings support the present investigation. Correlation studies between whitefly population and environmental parameter revealed that whitefly population had a significant positive correlation with temperature difference while significant negative correlation with relative humidity (maximum, minimum and average) (Table-1) [2]. Reported that the incidence of white fly population had a significant and positive correlation with temperature and sunshine hours while a negative correlation with relative humidity and total rainfall. This findings support the present investigation. The correlation with the temperature is slightly different because of location difference. On the other hand non-significant negative correlation was found between whitefly populations with temperature (maximum, minimum average) and weekly total rainfall. This indicates that activity of whitefly population increase with the rise of temperature and decrease of relative humidity.

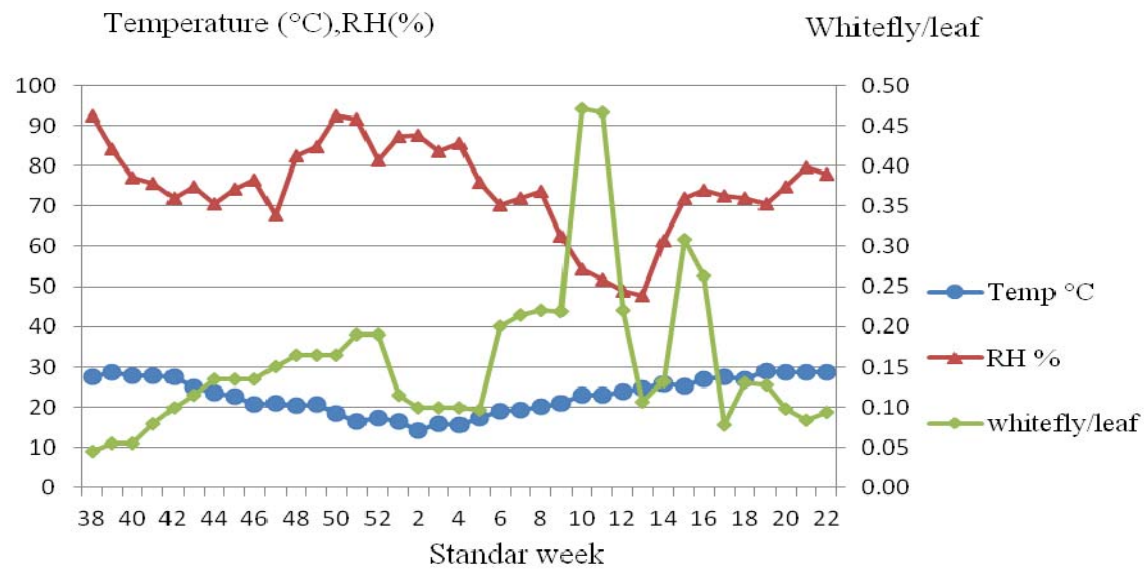

Fig.1 Incidence of Whitefly as influence by temperarue and RH

Table 1: Correlation co-efficient between whitefly and environmental parameters

Environmental parameter		Correlation co-efficient (r)	Co-efficient of determination (R^2)	Regression equation
Temperature ^{0}C	Maximum	-0.029	0.009	Y= -1.153X+29.548
	Minimum	-0.241	0.582	Y= -149.904X+18.505
	Difference	0.419**	0.175	Y=12.707X+11.056
	Average	-0.162	0.026	Y= -7.614X+24.052
Relative Humidity (%)	Maximum	-0.365*	0.133	Y= -36.991X+86.434
	Minimum	-0.572**	0.327	Y= -82.302X+81.210
	Average	-0.507**	0.257	Y= -59.646X+83.823
Rainfall(mm)	Weekly total	-0.286	0.082	Y= -129.36X+40.276

*Significant at 5% level of significance, ** Significant at 1% level of significance

The different treatments and their persistence at different days after application varied significantly in their suppression of whitefly populations (Table-2 and Table-3). The compounds evaluated under the present investigation provide moderate to higher control against whitefly. However, among the seven pesticides evaluated (Table-3) under the present investigation acetamiprid was found most effectively against whitefly providing 76.59% suppression, closely followed by extracts of neem+*Spilanthes* providing 62.39% suppression. From over all observation it was revealed that *Polygonum* extracts, neem pesticides, *Spilanthes* extracts, and tobacco extracts provide moderate results, recording about 56.74%, 54.92%, 51.75% and 43.74% whitefly suppression respectively. Least effectiveness against mite was recorded from garlic extracts providing 37.36% suppression only.

Three days after spraying, acetamiprid was found most effective against mite providing 82.17% suppression, closely followed by mixed formulation neem+*Spilanthes* extracts (71.29%) suppression. Extracts of *Polygonum* extracts, neem pesticides, *Spilanthes* and tobacco extracts were found to be moderately effective against whitefly providing 63.51%, 62.98%, 61.56% and 52.31% suppression respectively. The least effective results were found ingarlic extracts, 45.86% suppression. Seven days after spraying, extracts of *acetamiprid* was found to be most effective (75.76% suppression) against whitefly, closely followed by neem+*Spilanthes* extracts (63.26% suppression). Neem pesticides and *Polygonum* extracts and *Spilanthes* extracts were found to be moderately effective against mite providing 58.16%, 56.74% and 52.36%suppression respectively. The least effective control was found intobacco extracts and garlic extracts (47.71% and 40.00% suppression respectively). Eleven days after spraying, acetamiprid was found to be less superior insecticide (71.83% suppression) closely followed by neem+*Spilanthes* (52.62% suppression). Extracts of p*olyginum*, *neem pesticides and Spilanthes extracts* were found to be moderately effective against whitefly providing 49.97%, 43.61%, and 41.35%, suppression respectively [9].

Reported that the botanical insecticides Neemax (neem seed kernel extract) and Multineem (neem oil) regulated populations of this white fly. This findings support the present investigation. But when the neem product is used mixing with *Spilanthes* its activity becomes very high. The least control was found in tobacco extract and garlic extracts (31.21% and 26.41% respectively). From the overall observations it was revealed that acetamiprid extracts was found to be most effective against whitefly providing more than 75% suppression. Among botanical pesticides persistency is enough high for extracts of *Polygonum* where seven days after spraying higher whitefly suppression was observed than all other treatments. However, garlic extracts gave least effectiveness against whitefly control, recording only about 37.36% suppression.

Yield is the ultimate output to the farmer which makes them content. In this view, comparison has done for yield in order to find out effectiveness of botanical pesticide over tomato pests. Here over all yields is taken for evaluation. The lowest yield was recorded from control plots i.e. 18.32 t/ha (Table 4). Highest yield (30.15 t/ha) were recorded from acetamiprid treated plots followed by neem + *Spilanthes* (27.55 t/ha), *Spilanthes* extract (26.67 t/ha) and *Polygonum* extract (26.32 t/ha) which are significantly different from yield of other treated plots. Other than control plots the lowest yield were recorded from garlic treated (23.11 t/ha) plots closely followed by tobacco extract (24.02 t/ha) treated plots. From whole observation acetamiprid treated plots gave satisfactory yield but it is harmful as it is consumed by human being and it also contaminated the environment there by causing health hazard to other plant and animals. So, it is advisable to use neem + *Spilanthes* as a safety measure.

Table 2: Effects of different treatment schedules of plants extracts against whitefly (*Bemisia tabaci Genn.*) on tomato plants during 2011-2012 to 2012-2013

Treatments	Spray conc.	% Suppression of whitefly population on different days after treatment (DAT)									
		Season-I (2011-2012)					Season-II (2012-2013)				
		Pretreatment cont.	Days After treatment				Pretreatment cont.	Days After Treatment			
			3	7	11	Mean		3	7	11	Mean
T_1(Tobacco extract)	7.5%(75ml/L)	1.56	54.86 (47.79)	48.79 (44.31)	34.95 (36.24)	46.20 (42.78)	2.02	49.75 (44.85)	46.62 (42.95)	27.47 (31.59)	41.28 (39.80)
T_2 (Garlic extract)	5%(50ml/L)	1.55	46.09 (42.74)	42.72 (40.81)	25.85 (30.55)	38.10 (38.03)	2.12	45.62 (42.49)	37.27 (37.67)	26.97 (31.26)	36.62 (37.14)
T_3(Polygonum extract)	5%(50m/L)	0.89	62.44 (52.16)	57.14 (49.14)	54.31 (47.47)	57.96 (49.58)	1.55	64.58 (53.48)	56.34 (48.71)	45.62 (42.49)	55.51 (48.23)
T_4(Spilanthes extract)	5%(50ml/L)	1.07	60.67 (51.16)	50.43 (45.24)	44.22 (41.68)	51.77 (46.03)	1.87	62.44 (52.16)	54.28 (47.47)	38.48 (38.29))	51.73 (45.97)
T_5(Neem pesticides)	2.5ml/L	0.92	64.58 (53.48)	58.90 (49.93)	45.62 (42.49)	56.37 (48.63)	2.05	61.37 (51.58)	57.42 (49.06)	41.60 (40.16)	53.46 (46.93)
T_6(Neem + Spilanthes)	(1.5ml+ 40ml)/L	0.87	70.50 (57.13)	65.15 (54.91)	49.04 (44.45)	61.56 (52.16)	1.67	72.08 (58.12)	61.37 (51.58)	56.20 (48.57)	63.22 (52.62)
T_7(Acetamiprid)	1g/3L	1.33	76.98 (61.34)	70.45 (57.08)	73.21 (58.84)	71.55 (59.09)	2.15	87.35 (69.24)	81.07 (64.22)	70.45 (57.08)	79.62 (63.51)
T_8(Untreated control)	-	1.67	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	1.67	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)
SE(m)±	-	-	1.92	2.32	1.75	2.00	-	2.42	2.11	1.92	2.15
CD (5%)	-	NS	5.72	6.91	5.21	5.95	NS	7.18	6.22	5.72	6.37

Figure in the parenthesis are angular transformed values, DAT = Days after treatment, NS = Not significant

Table 3: Overall efficacy of plants extracts against whitefly (*Bemisia tabaci Genn.*) on tomato plants. (Grand Mean of 2011-12 and 2012-13)

Treatments	Spray conc.	% Suppression of whitefly population on different days after treatment (DAT)				
		Season-I and Season-II (2012-2013)				
		Pretreatment cont.	Days After Treatment			
			3	7	11	Mean
T_1 (Tobacco extract)	7.5%(75ml/L)	1.79	52.31 (46.32)	47.71 (43.63)	31.21 (33.92)	43.74 (41.29)
T_2 (Garlic extract)	5%(50ml/L)	1.84	45.86 (42.62)	40.00 (39.24)	26.41 (30.91)	37.36 (37.59)
T_3 (Polygonum extract)	5%(50m/L)	1.22	63.51 (52.82)	56.74 (48.93)	49.97 (44.98)	56.74 (48.91)
T_4(Spilanthes extract)	55(50ml/L)	1.47	61.56 (51.66)	52.36 (46.36)	41.35 (43.68)	51.75 (46.00)
T_5(Neem pesticides)	2.5ml/L	1.49	62.98 (52.53)	58.16 (49.50)	43.61 (41.33)	54.92 (47.78)
T_6(Neem + Spilanthes)	(1.5ml+ 40ml)/L	1.27	71.29 (57.63)	63.26 (53.25)	52.62 (46.51)	62.39 (52.39)
T_7(Acetamiprid)	1g/3L	1.74	82.17 (65.29)	75.76 (60.65)	71.83 (57.96)	76.59 (61.30)
T_8(Untreated control)	-	1.67	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)
SE(m)±	-	-	2.17	2.22	1.84	2.08
CD(5%)	-	NS	6.45	6.57	5.47	2.16

Figure in the parenthesis are angular transformed values, DAT = Days after treatment, NS = Not significant

Table 4: Yield potentiality in different treatments (2011-12 and 2012-2013)

Yield/t/ha				
Treatment	**Spray conc.**	**2011-12**	**2012-13**	**Mean**
T_1 (tobacco extract)	7.5%(75ml/L)	24.52	23.52	24.02
T_2 (Garlic extract)	5%(50ml/L)	22.24	23.98	23.11
T_3 (Polygonum extract)	5%(50m/L)	25.07	27.57	26.32
T_4(Spilanthes extract)	5%(50ml/L)	29.29	24.05	26.67
T_5(neem pesticides)	2.5ml/L	26.79	24.33	25.56
T_6(neem + Spilanthes)	(1.5ml+ 40ml)/L	27.99	27.11	27.55
T_7(Acetamiprid)	1g/3L	28.15	32.15	30.15
T_8(Untreated control)	-	16.46	20.18	18.32
SE(m)±	-	1.57	1.64	1.49
CD (5%)	-	4.76	5.01	4.53

4. Conclusion

These findings indicated that higher population level whitefly was maintained during 2nd week of March to 3rd week of March with peak population (0.47/leaf) recorded in the sub-Himalayan region of India. During these periods of the year drastic control measure should be adopted. Acetamiprid gave effective results but it is a highly toxic synthetic insecticide, so there is every possibility to contaminate tomato fruits with the toxic chemicals, as fruit is eaten. The azadirachtin and plant extract of *Polygonum* and *Spilanthes* gave moderate to higher whitefly suppression and produced higher yield. Based on their moderate to high efficacy levels, as well as low toxicity to natural enemies and minimum impact on human health, and higher yield potentiality we conclude that azadirachtin and plant extracts can be incorporated in future IPM programme and organic farming in vegetable cultivation.

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