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Research Article

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Dominance of physico-morphic plant traits in regulating population density of *Bemisia tabaci* and *Thrips tabaci* in Bt and non-Bt Cotton

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ABSTRACT

Policy makers, journalists and other commentators often advocate transgenic cotton (*Gossypium* spp.) as poor-performer against sucking insects that pose a great threat to production targets. A field study was carried out for seasonal occurrence of whitefly (*Bemisia tabaci* Gennadius) and thrips (*Thrips tabaci* Lindeman) on two of cotton genotypes namely *Bt* MNH-992 and non-*Bt* Cyto-124 under climatic conditions of Multan, Pakistan from July-October, 2017. Impact of environment as a factor was hypothesized on pests on two experimental sites [Research Area (RA) & Farmer Field (FF)]. Maximum population of whitefly at RA (13.5 and 16.7 individuals per plant) for *Bt* and non-*Bt*, respectively was recorded during SMW 40, while correspondent minimum populations (0.6 & 1.2 individuals per plant) was found during SMW28 in RA. The peak population of thrips was observed at RA during 30th SMW as (4.9 & 8.9 individuals per plant), respectively at *Bt* and non-*Bt* genotypes, declined to the lowest level of (0.1 & 0.3 individuals) in 41st SMW for both genotypes. *Bt*-cotton harbored relatively lower population of *B. tabaci* and *T. tabaci* in both fields owning to the presence of physico-morphich plant characters. A negative correlation of *B. tabaci* population was found with a maximum temperature and rainfall, and a positive relation with humidity. *T. tabaci* had a positive correlation with temperature and rainfall, and a negative correlation with relative humidity. The current research concluded that weather factors play and important role to increase or decrease the populations of sucking insect pests of cotton.

KEYWORDS: *Bemisia tabaci*, *Thrips tabaci*, climatic factors, physico-morphic characters

INTRODUCTION

Cotton (*Gossypium hirsutum*) being the king of natural fibers is popularly known as 'white gold' and 'silver fiber [1]. It is a great source of natural fiber inmost of cotton producing countries [2] whereas regarded as important cash crop and focus of textile industry in Pakistan. To meet increasing fiber demands today's world, need of cotton is now universally realized [3].

The environmental factors and insect pest lower production and deteriorate the quality of crop. Environmental changes may affect overwintering of insects that in return insect outbreak in following season. Secondly the dispersal of air borne insects is influenced as a result of atmospheric disturbances [4]. Pakistan has missed the revised cotton production target by around eight percent as the production has been recorded at 11.5 million bales against the revised target of 12.6 million bales for 2017-18 [5]. It has been recorded that around 10-40% of lint quality is affected by the attack of insects [6]. Major share of losses in cotton is taken by sucking insect pests particularly whitefly (*Bemisia tabaci*) and thrips (*Thrips tabaci*). Polyphagous and destructive nature of these insects is represented by sucking the sap and transmitting certain viral diseases [7]. Damage of whitefly is associated with the secretion of honeydew to invite sooty mold and mediating the role for transmitting cotton leaf curl virus [8]. Cotton plant is reported to produce 40% more lint in the absence of thrips as seedling at very younger stage are deteriorated if infested. Severe infestation of thrips turns leaves brownish at the edges, piercing of tissues epidermis, oozing of sap out of wounds and silvery appearance of leaves.

For last few years, rapid changes are witnessed in climate that are resulting drastic influence on the survival of insect pests especially on the survival, reproduction and feeding. Historically, insects facing such changes either undergo resurgence or complete removal from ecosystem. Climatic factors play a

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significant and driving role in regulating the population of sucking insects [9] mainly whitefly and thrips. The positive correlation has been observed with climatic factors for their development and seasonal abundance [10]. The major emphasis of the study is to observe the indirect effect on sucking insect pests. The present work was outlined to evaluate the relative performance of Bt and non-Bt cotton genotypes for harboring whitefly and thrips under field conditions in Multan and impact of weather factors in regulating population density.

MATERIALS AND METHODS

Experiment Details

The study was conducted during cropping season 2017 at two different locations located around 1 km away from each other; 1- Research Area of Muhammad Nawaz Shareef University of Agriculture, Multan (30.140242 N, 71.443662 E) and Farmer Field (30.145504 N, 71.452772 E) to compare the pest populations between the two cotton sowing areas. The reason for repeating the same study on two separate location is to provide variability in data that is on the other hand received from two years data. Both sites are similar in geographical features, however farmer field was chosen to verify the findings at university research area. Two cotton genotypes Bt (MNH-992) and non-Bt (Cyto-124) were sown under Randomize complete block design (RCBD) with four replications. Entire filed was divided into eight blocks, and block size (25 sq. feet) with recommended planting distance (P×P=9″) and (R×R=2.5″). During the whole cropping duration, all recommended agronomic practices were carried out uniformly in all treatments except plant protection operations. Both varieties were sown on 8th June and maintained according to standard agronomic practices for the area.

Data Recording

Population of *B. tabaci* and *T. tabaci* were recorded by pest scouting once every week from randomly 10 selected plants in each plot, one month after sowing and continued until the harvest time. Sampling procedures were adopted as per Naranjo and Flint [11]. observations were recorded continued from 9th July2017 up to 14th October 2017. Adult *B. tabaci* and *T. tabaci* were counted. All counts were completed between 06.00-08:00 am when the insects were expected to be actively feeding. No insecticides were sprayed for *B. tabaci* and *T. tabaci* to provide natural conditions for crop production except Triazophos 40 EC; FMC Pakistan and Deltamethrin 10.5 EC; Bayer Crop Sciences sprayed on August 7 and 13 for lepidopterous insect pests. Seasonal variation in population owning to the effect of climatic factors (temperature, humidity and rainfall) was observed as per standard meteorological weeks (SMW) for which data was obtained from Metrological Department of Central Cotton Research Institute, Multan, Pakistan.

Physico-morphic Characters

Both cotton genotypes selected for study were almost similar phenotypically, however non-Bt variety was long statured that Bt variety. Possible physico-morphic characters selected for study that can influence the preference and non-preference to either Bt or non-Bt were Hair length (μm), Hair density on midrib/mm, No. of gossypol glands/cm of midrib and Lamina thickness (μm). Ten randomly selected plants were chosen per plot and one leaf each from upper, middle and lower canopy was taken for physico-morphic studies with the help of Stereo Microscope (EXS-210) 2-4x magnification. The thickness of leaf lamina was recorded by cutting the cross section (1 cm^2) from three different places of each leaf with the help of a fine razor and thickness was measured by using an ocular micrometer under binocular microscope.

Statistical Analysis

Data recorded for *B. tabaci* and *T. tabaci* population were analyzed by analysis of variance in "Statistix v8.1" [12]. Treatment significance was determined by Tukey's HSD (α = 0.05) to separate the means. Correlation between population of *B. tabaci*, *T. tabaci* and weather factors were calculated in Statistix v8.1.

RESULTS

Population Density of *B. tabaci* and *T. tabaci*

The population of *B. tabaci*, and *T. tabaci* was recorded during meteorological weeks28-41 on two different locations within Multan (RA and FF). The results showed that peak population of *B. tabaci* was found during SMW-40 on Bt (13.5) and Non Bt (16.7 individual per plant) in RA, 16.4 and 16.6 individual per plant in FF respectively for Bt and non-Bt cotton. On the other hand, minimum population was recorded during week-28 (0.6 and 1.2 individual per plant, respectively in Bt and non-Bt cotton genotype for RA and 0.6 & 0.1 individual per plant for FF respectively (Figures 1 and 2).

Maximum count of *T. tabaci* was recorded on non-Bt than Bt cotton genotype during the 30th SMW while minimum was recorded at 41st SMW. The peak population of thrips was found in RA (4.9 and 8.9 individuals per plant) for Bt and non-Bt genotype during 30th SMW while in FF, population density for Bt and non-Bt remained 5.6 and 9.8 individuals per plant respectively. A similar trend of lowest population was recorded during 41st SMW when Bt cotton genotype harbored less density that Bt for RA and FF (Figures 1 and 2). Lowest population during 41st SMW was observed when the crops was towards the maturity stage.

Physico-morphic Characteristics

Physico-morphic characteristics of the leaves that were supposed to affect the preference or non-preference were found correlated with population density of *B. tabacic* and *T. tabaci*. Hair length(μm), hair density on midrib/cm, number of gossypol glands/cm of midrib and lamina thickness (μm) was observed maximum on non-Bt cotton genotype in both cotton genotypes. Significant difference were found for hair length (μm) on

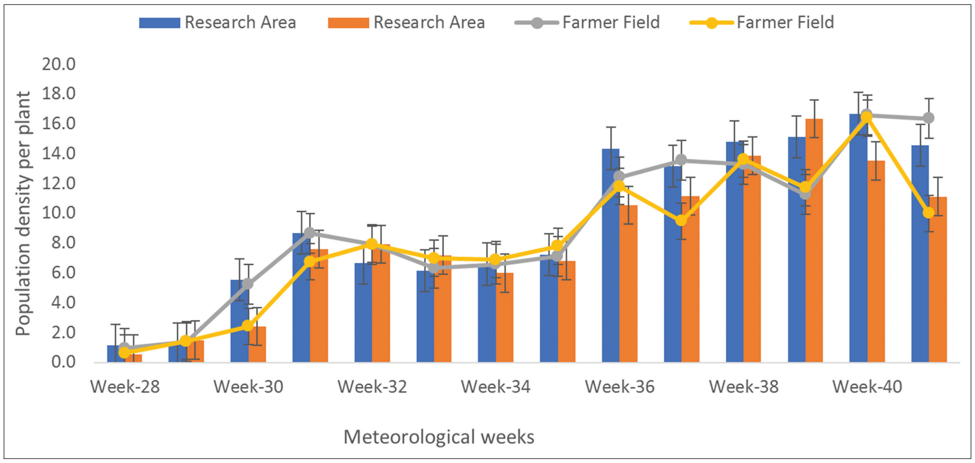

Figure 1: Population density of *B. tabaci* in cotton crop on Bt and non-Bt varieties at different metrological weeks during 2017

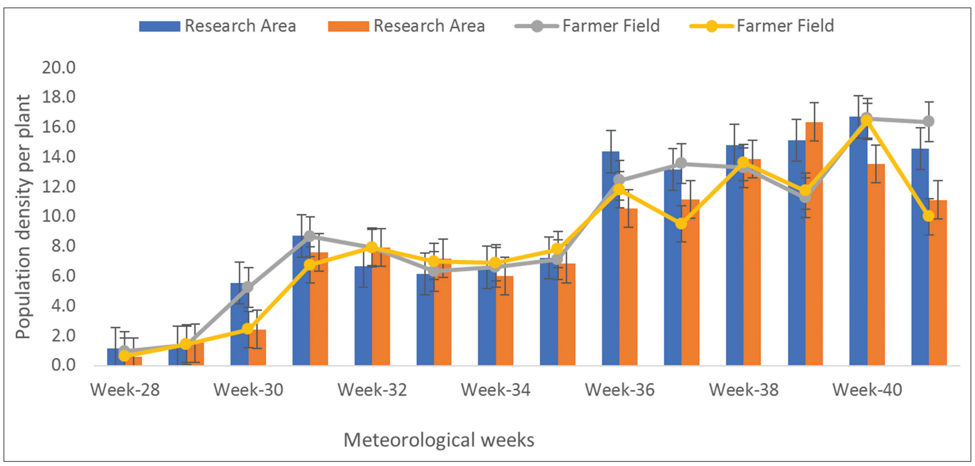

Figure 2: Population density of *T. tabaci* in cotton crop on Bt and non-Bt varieties at different metrological weeks during 2017

midrib [$F=3.65$, $P<0.01$], hair density on midrib/mm [$F=6.57$, $P<0.01$], No. of gossypol glands/cm of midrib [$F=14.3$, $P<0.01$] and lamina thickness [$F=9.82$, $P<0.01$] with highest values in non-Bt cotton genotype (Figure 3).

Correlation between Weather Factors and Population Density

Weather factors were found to affect the population density of *B. tabaci* and *T. tabaci* and average temperature and average humidity were recorded to be 28.4°C and 77.40% respectively. *B. tabaci* population was found negatively correlated with temperature and rainfall whereas positively correlated with relative humidity. *T. tabaci* on the other hand was negatively correlated to humidity but positively correlated to temperature and rainfall (Tables 1 and 2).

Table 1: Correlation coefficient for population density of *Bemisia tabaci* and *Thrips tabaci* in relation to weather factors during 2017

Research area	Temperature	Humidity	Rainfall
B. tabaci			
Non-Bt	−0.766	0.564	−0.448
Bt	−0.810	0.508	−0.438
T. tabaci			
Non-Bt	0.530	−0.456	0.484
Bt	0.366	−0.347	0.367
Farmer field			
B. tabaci			
Non-Bt	−0.796	0.523	−0.441
Bt	−0.757	0.499	−0.469
T. tabaci			
Non-Bt	0.556	−0.493	0.310
Bt	0.367	−0.278	0.456

DISCUSSION

Association of insects and their host crops is governed by natural factors (i.e. biotic and abiotic). Biotic factors can be manipulated using breeding and biotechnological approaches. Abiotic factors on the other hand cannot be altered manually or mechanically. However, abiotic factors like temperature, humidity, rainfall etc. provide strongest clues for understanding trends of insect outbreak and infestation. Transgenic cotton is known as specialist to produce natural insecticide in its tissues for lepidopterans. However, apparently this has nothing to do with sucking insect complex in cotton. Some researchers pointed out the relatively low incidence of sucking insects in transgenic cotton [13] as reported in the present study. Although Bt cotton owing to have a unique physiological set up against lepidopteran

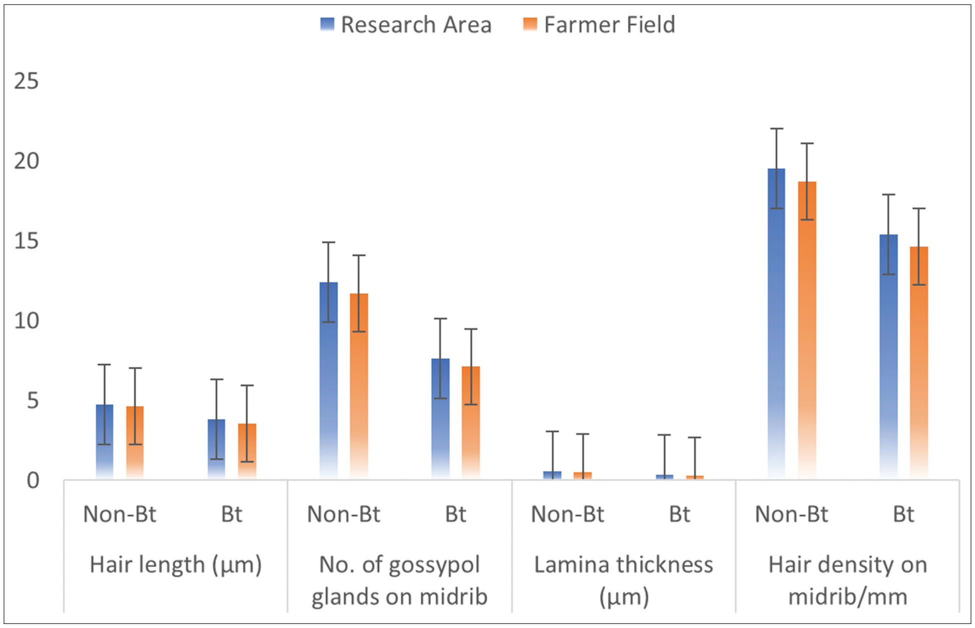

Figure 3: Physico-morphic characters of Bt and non-Bt cotton during 2017 influencing population density of *B. tabaci* and *T. tabaci*

Table 2: Climatic factors recorded for standard meteorological weeks during 2017

Meteorological weeks	Temperature (°C)	Humidity (%)	Rainfall (mm)
Week-28	33.5	70.2	2.3
Week-29	33.1	69.4	0.0
Week-30	33.4	72.4	5.2
Week-31	31.9	72.9	0.0
Week-32	31.3	67.7	0.0
Week-33	32.1	73.4	0.0
Week-34	32.5	79.9	13.0
Week-35	29.6	77.1	13.5
Week-36	32.1	79.1	0.0
Week-37	30.9	76.6	0.0
Week-38	30.1	77.5	0.0
Week-39	28.8	76.8	0.0
Week-40	28.4	77.4	0.0
Week-41	27.9	76.9	0.0

insect pests, but plant's morphological characteristics may disrupt some insect activities by producing physical stimuli [14]. The variation in insect density was found related to physico-morphic characteristics expressed more in on-Bt-cotton genotypes. Positive correlation of population density of *B. tabaci* and *T. tabaci* with gossypol glands [15], and hair density on stem internodes and midrib favours our hypothesis. Some researchers contradict our statement of low population incidence of whitefly and thrips on non-Bt genotype than Bt genotype [16] possible reason for it can be plant characters of varieties grown. Understanding the trends in population buildup of insects associated with weather factors and physico-morphic plant characters helps to predict the behavior and hence can help to lower the infestations on the other hand. This can be a valuable tool for cotton crop managers who are vigilant to minimize the crop losses encountered by sucking insects. Changing climatic conditions is not only affecting the human activities associated with farming i.e. cropping pattern, sowing and harvesting time. Under this changing scenario, outbreak of insect pests is being shifted. Weather factors are regulating the population density of major insect pests of cotton. Temperature has dominant role in pest population variation [17], while relative humidity shows negative correlation with whitefly population [18] that support the findings of present study. Population of whitefly in this study is found negatively correlated to temperature and positively correlated to humidity. This is in agreement with previous study [19].

While selecting cotton as cash crop, one has to consider planting dates, varietal traits and role of environmental factors. Climate had powerful effects on the distribution and abundance of the insect species, and this could lead to alteration is ecosystems insects inhabit. Future changes in climate can significantly modify the outbreak dynamics of certain insect species. This may result in recurring insect outbreaks or complete disruption of a particular species from an ecosystem. Insects which use thermal cues to acclimatize under changing conditions, fluctuation in temperature can advance the onset of insect life cycles. Due to short life cycles, high fecundity and great mobility, physiological responses of insect to changing temperatures exerts rapid and notable effects on species population dynamics. Changing temperature fluctuate the conditions for the survival of insects as rise in temperature favors the metabolic activities, food assimilation and helps readily complete the life cycle. On the other hand, RH and rainfall makes condition hard for survival of insects as humidity favors the disease causing agents of insects.

CONCLUSIONS

In the light of these findings, the initial enthusiasm for Bt cotton being equipped with technology for bollworms would be considered by a more cautious economic benefit for sucking insect pests by crop trait. The findings can provide impetus and solid ground for cotton breeders with a direction for future plant selection criteria. This paper presents a detailed, critical re-examination of the evidence base underlying the claim that GM crops can produce benefits for bollworms only can be revised with a range of benefits for sucking insect pest complex. Future farming would greatly rely on the comprehensive analysis of all the factors determining the life cycle, fecundity and nutrition assimilation in insects. Further concurrent researches would increase our understanding of the complexity of insect dynamics for predicting impacts associated with plant traits and climate.

List of Abbreviations

Bt: Bacillus thuringiensis
GM: Genetically modified
RA: Research Area
FF: Farmer Field
SMW: Standard Meteorological Week
RCBD: Randomized Complete Block Design
EC: Emulsifiable Concentrate

Competing Interests

The authors declare that they have no competing interests

AUTHORS' CONTRIBUTIONS

All authors participated in the development and implementation of the research plan and subsequently written. All authors contributed to the writing and approved the final manuscript.

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Significant Statement

This study is very helpful for entomologist and farmers because it provides marked information about the management of whitefly and thrips on cotton under changing climatic system.

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