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Evaluation of Population Dynamics of Sucking Pests on Bt and Non Bt Cotton Cultivars

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AA performed the experiment, reviewed the literature and analyzed the data. AF provided technical support and reviewed the article.

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ABSTRACT

The purpose of current study was to highlight the population dynamics of sucking pests on Bt cotton varieties (Lalazar, IUB-33, Sitara-009and MNH-988) and one non-Bt (NIAB) varieties in Multan Southern Punjab, Pakistan. During 2014 to 2016, eggs count and adult population of five different sucking pests (dusky bugs, jassid, thrips, white flies and mites) were recorded from sowing to harvesting seasons. Predators (*Chrysoperla, Geocoris* and *Argiope*) population was also observed. Percentage of host plant susceptibility index (HPSI) for each cotton variety was also calculated. One way ANOVA was used to analyzed the data statistically. Variety and year had significant ($P<0.05$) effect on pest populations, eggs count and predator's populations. It was found that Bt cotton was more resistant to pest attacks than non-Bt. Therefore Bt cotton should be grown to combat pest infestation.

INTRODUCTION

Among the cotton producing countries, Pakistan is one of the key producers with the average yield of 570.99 kg/ha. This is lesser than the other cotton producing countries (Bakhsh *et al*., 2005). There are many factors for this low yield such as severe heat waves, lack of irrigation facilities and advanced technology, low literacy rate of farmers, high price of pesticides, adulteration in pesticides and high intensity of insect and pest attack (Ahmad and Sarwar, 2013). Pattern of infestation of pest has changed due to cultivation of Bt cotton over the years. Among different types of insects pests that infest the cotton crop, sucking and chewing pests have been problematic (Aslam *et al*., 2004; Amjad and Aheer, 2007). As a common observation, the chewing insect pests died on eating the vegetative parts of Bt cotton variety but entered to the next stage of life in non-Bt cotton crops. While, sucking pest like thrips (*Thrips tabaci)*, jassid (*Amrasca bigutella*), cotton aphid (*Aphis gossypii*), mites (*Tetranychide acarira*) and white fly (*Bemisia tabaci*), have also been known to effect non-Bt as well as Bt cotton cultivars (Shah *et al*., 2017). These pests cause damage by sucking the cell sap during seedling and vegetative phase of plant which results in plant weakening and in case of severity shedding of leaves or wilting occurs (Abro *et al*., 2004). Surprisingly, it has been observed that Bt varieties of cotton needs fewer sprays than non-Bt varieties. Pesticides are mainly used to eradicate sucking pests. Bt cotton has an ability to produce natural toxins against chewing pests to minimize the use of pesticides (Kang and Frasat, 2010). Numbers of investigations have proved that varieties of Bt cotton are pest resistant that eventually decrease the yield loss and strengthen the economy as compared to non-Bt cotton. Lot of efforts are being made to improve the quality of Bt cultivar of cotton, so that the sucking pest may not attack the crop (Choudhary and Gaur, 2010). It is an established fact that pesticides are used to control the sucking pests. Cotton yield can be enhanced by using different Bt and non Bt cotton varieties that are supported by the abiotic factors and local agronomic conditions of southern Punjab. In Pakistan, previously NIAB-78, CRIS-134 and CIM-496 were farmed, while in 2010, new Bt varieties and non Bt varieties *i.e.* SITARA-009, MNH-986, Lalazar, IUB-33, FH-114 CIM-598, and NIAB, CIM-573 MIAD-852, respectively were approve by Government of Pakistan (Khan *et al*., 2010). The studies on population dynamics of insect pests were lacking in southern Punjab therefore the present study aims at understanding the difference in infestation of sucking pests on Bt cotton compared to non-Bt cotton.

MATERIALS AND METHODS

Experimental site and design

The current research work was planned in cotton growing region of three districts of southern Punjab region designated as Site-I (Multan), Site-II (Khanewal) and Site-III (Vehari) during 2014-2016. Cotton was grown in ten different randomly selected plots in the study areas which

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were away from each other. Local agronomic practices were adopted. Seeds were purchased from local market at the rate of Rs.300/kg for Bt and Rs 250/Kg for non-Bt varieties. Before sowing, the seeds were treated with 95% conc. H_2SO_4 to remove the fuzz on cotton seeds. Raised beds were prepared at the distance of 2.5 ft from each other. Two to three seeds were placed on these raised beds at the distance of 25cm from each other. Irrigation was supplied time to time when needed, urea and diamonium phosphate (DAP) were used as fertilizers. No pesticides were used. Plants were tagged in each field by using sign board at suitable places for enumeration purpose.

Sampling

Number of adults and eggs of five types of sucking pests of cotton (white flies, jassid, mites, dusky bugs, and thrips) along with their predating insects like *Chrysoperla, Geocori*s and *Argiope* were recorded from experimental sites. Sampling was done from sowing to harvesting after one month interval. Eggs and adults count of five cotton sucking pests was started when seedling erupted from the soil and the leaves appeared.

Data analysis

The data on egg counts and adults were analyzed by using one way analysis of variance (ANOVA) with the computer software *i.e.* Statistix Software (Version 8.1) and mean were separated at 5% level of significance. Following formula was used to calculate the host plant susceptibility index:

$$\text{HPSI (\%)} = \frac{B - A}{B} \times 100$$

Where, A is population of pest (adult/eggs) in individual variety and B is population of pest (Adult/egg) in all varieties on average basis.

RESULTS

Result showed varietal differences for adult populations of dusky bugs, jassid, white flies and thrips were significant (P<0.5) but non-significant differences for mites. Variety differences for predator population were found non-significant at site-I (Table I). Eggs of mites were non-significant while other shows significant difference at site I. The average number of eggs of different sucking pests except mites was significantly different at site-I (Table II). Significant differences regarding variety were observed for all adult sucking pests at site II. Predators' populations were non-significantly affected by variety except *Chrysoperla* (Table I). Varieties have significant (P<0.01) influenced on average number of eggs of different sucking pests except dusky bugs and white flies at site-II. At site-III, average adult populations of mites, white flies and dusky bugs were significantly (P<0.05) affected by variety. Population of *Geocoris* was significantly differed for varieties (Table I). Variety had significant influence on average number of eggs (Table II).

Table I.- ANOVA for population counts of sucking pests and their predators.

	Variable	Jassid	Dusky bugs	Mites	Thrips	White fly	*Geocoris*	*Chrysoperla*	*Argiope*
Site I	Year	11.86***	10.55***	6.21**	24.10***	12.50***	4.86*	1.88ns	3.89*
	Variety	30.54***	11.18***	0.88ns	23.62***	33.87***	0.33ns	1.12ns	0.29ns
Site II	Year	10.44***	20.60***	41.60***	16.47***	14.38***	3.57*	0.03ns	1.10ns
	Variety	9.20***	3.99***	15.67***	8.54***	11.69***	1.90ns	3.79*	2.32ns
Site III	Year	85.33***	50.73***	37.14***	167.35***	34.34***	0.22ns	0.19ns	2.38ns
	Variety	1.94ns	19.73***	14.87***	0.90ns	5.53***	3.88*	0.49ns	0.53ns

Given values are F values from ANOVA showing significance difference. *, significant; **, highly significant; ***, very highly significant; ns, non-significant.

Table II.- ANOVA for eggs counts of sucking pests.

	Variable	Jassid	Dusky bugs	Mites	Thrips	White fly
Site I	Years	15.61***	4.12*	5.48**	14.16***	10.62***
	Varieties	17.13***	3.66*	1.45ns	21.95***	24.33***
Site II	Years	2.99ns	7.45*	21.64***	22.13***	4.52*
	Varieties	4.61*	2.33ns	14.60***	12.04***	0.96ns
Site III	Years	8.57***	16.32***	23.10***	4.38*	16.95***
	Varieties	8.21***	4.10***	21.02***	6.65***	2.82***

Given values are F values from ANOVA showing significance difference. *, significant; **, highly significant; ***, very highly significant; ns, non-significant.

Adult population of sucking pests on cotton cultivars at three experimental sites

At Site I, the maximum and minimum average number of adult jassid and dusky bugs were recorded on MNH-988, NIAB non-Bt and Lalazar, Sitara-009 varieties, respectively. The maximum number of white flies, thrips and mites was seen on Sitara-009 to be highest on MNH-988. Thrips observed more on IUB-33 while mites had low population. Lowest number of mites and highest population of thrips were noted on Lalazar. For MNH-988, NIAB non-Bt and Sitara-009, Thrips and mites had the highest and lowest number of adults, respectively. Mites had the lowest and thrips had the highest population on Sitara-009 variety (Supplementary Table I). At Site II, jassid and white fly population was found to be highest on Sitara-009 while it was lowest on NIAB non-Bt. Highest and lowest adult population of dusky bug and mites was observed on MNH-988 and Lalazar accordingly. Cotton variety IUB-33 and NIAB non-Bt was found to be highest and lowest population of thrips, respectively (Supplementary Table II). At site-III varieties of cotton namely IUB-33 and Sitara-009 had the highest and lowest jassid population, respectively. Highest and lowest numbers of dusky bug were found on IUB-33 and MNH-988, while mites' population was noted highest on Sitara-009 and lowest on IUB-33, whereas population of white fly was recorder highest on IUB-33 and lowest on NIAB non-Bt, on the other hand thrips were highest on NIAB non-Bt and lowest on Sitara-009 (Supplementary Table III).

Egg counts of sucking pests on different cotton varieties at three experimental sites

Average egg count of sucking pest was recorded on different cotton varieties at site I. The maximum average of jassid eggs was found on NIAB non-Bt and minimum on IUB-33. Eggs counts of mites and dusky bugs were found to be highest on Sitara-009, while it was lowest in Lalazar and MNH-988, respectively. Highest and lowest eggs count of white fly and thrips were noted on NIAB non-Bt and MNH-988 accordingly (Supplementary Table I). The average egg counts of various sucking pests were also noted at site II. The highest average number of eggs of white fly and jassid was observed on IUB-33, while their lowest numbers were recorded on MNH-988 and Lalazar, respectively. The corresponding lowest and highest counts of eggs of dusky bugs were recorded in cases of Lalazar and Sitara-009 varieties. Highest egg counts of thrips and mites were seen on NIAB non-Bt while lowest number of mites on IUB-33 and thrips were found to be lowest on Lalazar (Supplementary Table II). Average eggs count of various sucking pests was recorded at site III. Jassid and thrips egg count was recorded highest on NIAB non-Bt while lowest egg count was found on MNH-988. Lowest and highest egg count of mites and dusky bugs were noted on Lalazar and Sitara-009, respectively. White fly eggs count was more on IUB-33 and lesser on Lalazar (Supplementary Table III).

Yearly fluctuation in adult populations and egg counts of sucking pests at three experimental sites

Yearly fluctuations of adult and eggs count of sucking pest were also recorded at three study sites (Supplementary Tables V, VI, VII). At site I, egg counts and adult populations of jassid, white fly and thrips were increased while mites egg count and adult population was decreased, however, dusky bug population showed an unusual trend from 2014 to 2016 (Supplementary Table V). At site II, egg counts of jassid and thrips gradually decreased while adult populations were gradually increased from 2014 to 2016. The increase in the adult pest population in the study area might be due to migration of the pets from neighboring areas. Dusky bug and mites egg counts and adult population gradually decrease from 2014 to 2016 (Supplementary Table VI). At site III, adult populations of all sucking pests (jassid, thrips, white fly, mites and dusky bugs) were gradually increased from 2014 to 2016 (Supplementary Table VII).

Population of predators on different varieties of cotton at three experimental sites

Among the predator population *Geocoris* was highest on Lalazar and lowest on Sitara-009, while population of *Chrysoperla* and *Argiop*e was more on NIAB non-Bt and lowest on MNH-988 and Lalazar, respectively. Predators' populations of *Geocoris*, *Chrysoperla* and *Argiop*e were found to be highest on NIAB non-Bt, while lowest number of *Geocoris* was noted on Lalazar and *Chrysoperla*, *Argiop*e was on IUB-33 (Supplementary Table IV). At site-III, populations of predators of sucking pests showed that *Chrysoperla*, *Argiop*e and *Geocoris* were noted highest on IUB-33 variety. Within each variety highest and lowest populations, all cotton varieties under study had highest *Geocoris* and lowest *Chrysoperla* populations (Supplementary Table IV).

Host plant susceptibility index (HPSI) at three experimental sites

Host plant susceptibility index for cotton cultivars from 2014-16 are provided in Table III.

HPSI was lowest for Sitara-009 and highest for IUB-33 varieties at site I during 2014. MNH-988 was found to have highest HPSI in 2015, followed by Lalazar, Sitara-009 and other varieties. During 2016, the minimum and maximum HPSI was recorded for NIAB non-Bt and MNH-

988 varieties, respectively at site-I. The highest values of HPSI were observed for Lalazar, Lalazar and NIAB non-Bt varieties, during 2014, 2015 and 2016, respectively. The related values for MNH-988, Sitara-009, and IUB-33 cotton varieties were recorded low, respectively at site-II. At site-III, highest HPSI percentages were recorded for Sitara-009, Lalazar, and NIAB non-Bt varieties from 2014 to 2016. NIAB non-Bt, MNH-988, Sitara-009 have lowest HPSI in 2014, 2015 and 2016, respectively.

Table III.- Host plant susceptibility index for five cotton verities at three experimental sites.

Year	Variety	Host plant susceptibility index (%)		
		Site I	Site II	Site III
2014	Lalazar	79.44	85.70	79.36
	IUB-33	81.67	84.50	79.63
	Sitara-009	79.01	74.84	87.15
	MNH-988	80.26	71.95	79.02
	NIAB Non Bt	79.61	83.01	74.83
2015	Lalazar	82.18	90.85	85.11
	IUB-33	78.24	83.34	83.02
	Sitara-009	71.02	67.87	84.47
	MNH-988	91.95	74.93	72.79
	NIAB Non Bt	76.61	83.00	74.61
2016	Lalazar	91.31	73.49	79.45
	IUB-33	85.16	61.90	76.04
	Sitara-009	75.02	84.35	71.14
	MNH-988	92.73	88.75	85.43
	NIAB Non Bt	55.78	91.51	87.95

DISCUSSION

Different varieties and strains of cotton have been developed by using the technique of genetic engineering since last few years. Gene modification plays an important role to develop the resistant strains and varieties of cotton against the pests attack and their diseases (Anonymous, 2011). Nowadays, it is common practice to use genetically modified (Bt cotton) varieties to obtain higher yield. Government of Pakistan has recommended cultivating different strains of Bt cotton like Sitara-009, MNH-988, Lalazar and IUB-33 along with other non-Bt varieties all over the country particularly in the cotton growing region of the south Punjab (GoP, 2016). These varieties show remarkable resistance and variable performance especially against insect pests. The current study evaluated the population dynamics of sucking pests invading non-Bt and Bt cotton cultivars. These varieties displayed resistance against the pests depending upon species of insect pests. The non-Bt variety is more susceptible to attack of large number of pests while Bt cultivar were less susceptible because of its resisting power. Large number of insect pests attacked on the non-Bt cotton variety as compared to the Bt variety, that was lagging behind in resistance. Different type of pests especially sucking pests played a havoc role resulting into huge economic losses by destroying cotton crop. The current study focused on the influence of different pests (jassid, dusky bug, thrips, white fly, mites) and their predators (*Geocoris, Chrysoperla*, *Argiope*) inhabiting on these recommended varieties. Population of jassid was higher on non-Bt as compared to the Bt strains (Supplementary Table I). Bt cotton varieties was bearing less pest population than non-Bt. The highest number of jassid population showed that non-Bt variety had less resistance than Bt strain. Where jassid are problematic insect there Bt strain are more suitable to cultivate. Dusky bug population was almost same on all Bt and non-Bt varieties reaching a maximum. It meant that these varieties possessed almost equal resistance for this insect but population of dusky bug was lower than jassid on these strains. The lowest number of mites in comparison to the other insect populations on these varieties indicated that they faced maximum resistance than other insects. Population of thrips was higher on all these strains but non-Bt variety possessed the highest number which indicated that it had lower resistance than Bt cultivars. Population of white flies was also higher on non-Bt than Bt cotton. The results indicated that Bt cotton due to its resistance was more appropriate to cultivate. Patil *et al*. (2014) observed lesser number of sucking pests on Bt cotton as compared to non-Bt cotton which is in favour of current study. Hole *et al*. (2013) studied on sucking pests they revealed that Bt varieties haven't any protection against sucking pest due to its genetic and morphological bases that was not in favour of recent work.

At site I, eggs count of dusky bugs, white flies and jassid was higher on non-Bt varieties as compared to the Bt cotton indicated that they had more affinity with non-Bt than Bt cotton (Supplementary Table I). Mites had lowest number of eggs on Bt as compared to non-Bt while white flies and jassid had maximum number of eggs, respectively (Supplementary Table I). Therefore, Bt varieties due to its resistance against different pests are highly recommended to cultivate in this region. It was surprising that population of dusky bug, jassid and mites were higher on Bt cotton variety than non-Bt variety at site-II and site-III. The most appropriate choice for these regions to sow was Lalazar due to its resistance against mites and dusky bugs but Lalazar was more susceptible to attacks of white fly and thrips (Supplementary Tables II, III). Eggs counts of jassid were almost similar on all these Bt varieties which was

lower than non-Bt. All Bt varieties were bearing nearly equal number of eggs of jassid, that was generally lower than for non-Bt cotton (Supplementary Tables II, III). The similar finding has been reported by different scientists in the world (Jeyakumar *et al*., 2008; Arshad *et al*., 2009; Abdullah, 2010; Sabir *et al*., 2011; Solangi *et al*., 2014). Sitara-009 had highest number of eggs while other Bt strains had lowest number of eggs count of dusky bugs. Mites and thrips eggs were more on non-Bt than Bt. White flies laid highest number of eggs on all Bt varieties which shows that this insect had less resistance at site-II (Supplementary Table II). Jassid laid more eggs on non-Bt while dusky bugs and mites eggs counts were higher on Bt strain. White flies eggs count were lower on all these varieties at site-III (Supplementary Table III). In short the cultivation of Bt cultivars was better than non-Bt to resist the attack of pests in this region. Some predators also had affinity for these pests but their population was quite low. Population of different predators such as *Chrysoperla, Argiop*e and *Geocoris* was higher on non-Bt cotton. Predator's population also indicates that pests attacks more on non-Bt variety where they found more food there. The number of *Chrysoperla* was higher at site-II (Supplementary Tables IV, VIII). Population of predators was more at site-II than site-I which indicated presence of more prey. At site-III, Predators population was higher than site-I and lower than site-II depending upon the pest population (Supplementary Tables IV, VIII). Presence of predators shows a strong relation with the pests on all these three sites. Higher population of predators was recorded on non-Bt variety at all these sites (Supplementary Table IV). The current findings for predators were supported by Sarwar (2013).

Genetically modified varieties of cotton show more resistance against the attack of various sucking pests that reduces the production loss in this area of South Punjab. Some of them show better performance against the pests that must be promoted to cultivate. Population of adults and their eggs count was a good indicator of resistance. Thrips, white fly, dusky bugs, jassid and mites were commonly infesting the crop in these cotton belts. Mites were generally found lower in number than other ones. Predators were also found in this region but their number depended on the prey population size (Supplementary Table VIII). Usually, non-Bt cotton variety was more susceptible to be attacked by these pests than Bt varieties (Supplementary Table IV). The strong relation between predators and pest was also noted where they (pest) indicated their (prey) number in this region. Therefore, it is suggested that Bt cotton varieties should be cultivated to reduce the pest infestation and minimize the quantitative as well as qualitative losses to the cotton produce.

Supplementary material

There is supplementary material associated with this article. Access the material online at: http://dx.doi.org/10.17582/journal.pjz/2019.51.3.1093.1098

Statement of conflict of interest

The authors declare no conflict of interest.

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