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PERFORMANCE OF SOME TRANSGENIC COTTON CULTIVARS AGAINST INSECT PEST COMPLEX, VIRUS INCIDENCE AND YIELD

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Five cultivars of cotton i.e., 'IR4-NIBGE', 'IR5-NIBGE', 'Bt-121', 'Sitara-10M' and 'Sitara-11M' were screened for resistance against insect pest complex and Cotton Leaf Curl Virus (CLCuV) incidence in the research area of Cotton Research Station, Multan. The result depicted that the most resistant variety against jassids was 'IR4-NIBGE' and 'Sitara-11M' whereas 'IR4-NIBGE' showed the maximum resistance against whitefly infestation. The least susceptible variety to the infestation of thrips was 'Sitara-10M'. The most susceptible variety to the prevalence of Red Cotton Bug (RCB) was 'IR4-NIBGE'. The genotype 'Bt-121' showed the attack of spotted bollworm. The high population of Dusky Cotton Bug (DCB) was observed on 'Bt-121' throughout the season. The incidence of virus percentage increased with the passage of time; however, the variety 'IR5-NIBGE' exhibited maximum level of tolerance. Variety 'Bt-121' gave the maximum yield i.e., 1852 kg per acre followed by 'IR5-NIBGE', 'Sitara-11M', 'Sitara-10M, 1584, 1503, 1466 kg per acre respectively. Our results suggest that IR4-NIBGE and Sitara -11M are comparatively tolerant to jassids and whitefly which are the yield losing pest. So IR4-NIBGE and Sitara -11M varieties can be included in IPM programme for the management of these voracious pests.

Keywords: Host plant resistance, transgenic cotton, insect pest complex, virus, yield

INTRODUCTION

Cotton, *Gossypium hirsutum* L. is commonly known as silver fibre, is the backbone of Pakistan (Tayyib *et al.,* 2005). Being the king of natural fibre, it contributes about 68% to the foreign exchange earning of our country (Khan and Khan, 1995). Pakistan ranks 4th in cotton production among the cotton growing countries of the world (Anonymous, 2012-13) but cotton yield is low as compared to other cotton growing countries of the globe. There are number of constraints which currently cotton is facing. Insect pest are the main threat to cotton production (Ahmad *et al*., 2011). The severe attack of sucking insect pest complex plays fundamental role in reducing the yield (Aslam *et al.,* 2004). Worldwide about 162 species of insect pests have been recorded which attack on various growth stages of cotton (Kannan *et al.,* 2004). The insect pest complex on cotton crop can be divided into two categories; sucking and chewing insect pests. Among sucking pests, i.e. jassid [*Amrasca bigutella bigutella* (Dist.)], whitefly [*Bemisia tabaci* (Genn.)] and thrips [*Thrips tabaci* (Lind)] are the most dangerous which suck the sap from leaves and deteriorates the food factory, dusky cotton bug and red cotton bugs reduced the seeds germination and lint quality. Whereas among chewing insect pests, i.e. spotted bollworms (*Earias spp.*), pink bollworm [*Pectinophora gossypiella* (Saund)] and American bollworm [*Helicoverpa armigera* (Hub)] are the boll feeders.

But due to the introduction of transgenic cotton the sucking pest go on increasing rapidly. The nymphs and adults of these pests not only suck sap from leaves and reduced the photosynthetic area of the plant but also cause damage to the crop by injecting its toxic saliva into tissues (Borah, 1995; Patel and Patel, 1998; Rafique and Shah, 1998; Sudhakar *et al*., 1998). For example whitefly (*B. tabaci*) transmits viral diseases like deadly CLCuV (Khan and Khan, 1995). Due to severe attack of CLCuV in 1992 the area under cotton approximately 243949 acres was suffered with significant losses of 543294 numbers of bales (Anonymous, 1995). Whitefly also deteriorates the lint by secreting honeydews which renders the excellence of fibre and make it unfit for marketing (Denhoia and Birnie, 1990). The horrible insect pests cause 5-10% loss in cotton which increased up to 40-50% in case of their severe attack (Naqvi, 1976). Whiteflies impose heavy losses to the cotton crop from seedling to the harvesting stage and reducing its yield and quality (Ameer *et al*., 1999). Cotton jassid (*A. devastans*), and thrips (*T. tabaci*) are reported to cause 24-50% (Bhat *et al*., 1986; Sakimura, 1963) and 38% (Attique *et al*., 1990) reduction in yield. Overall losses during 1998-99 due to pest attack in cotton were found to be 3.1 million bales (Ahmad and Poswal, 2000). There are various pest control measures but

the varietal resistance which involves no or small use of insecticides holds great importance (Bughio *et al*., 1984; Jin *et al.,* 1999; Khan *et al*., 2003). Growing of insect resistance varieties is not only economical but also safer for the environment (Pedigo, 1989; Khan and Sexena, 1998). The use of resistant varieties offers an inexpensive preventive measure, which is generally compatible with other methods of pest control (Chauhadry and Arshad, 1989). The breeders have focused their attention to increase the yield potential and evolved a number of varieties for this purpose. There are also many plant characteristics which can affect positively or negatively on the plant feeders and their natural enemies (Krips *et al*., 1999; Afzal and Bashir, 2007).

Keeping in view the challenges of sucking pests the present studies were conducted to screen out some transgenic cotton genotypes against insect pest complex, virus incidence and yield for the betterment of grower's income.

MATERIALS AND METHODS

The experiment was conducted at Cotton Research Station, Multan during 2012 in RCBD having five treatments with three repeats each. There were six rows in each treatment per replicate. The five cotton cultivars i.e. IR4-NIBGE, IR5-NIBGE, Bt-121, Sitara-10M, Sitara-11M were sown on 30.05.2012. The plot size was kept 15 ft x 10 ft. The data was recorded weekly from germination to the month of October. The population of sucking insect pests like whitefly, (*Bemisia tabaci*), jassid (*Amrasca bigutella bigutella*) and thrips (*Thrips tabaci*) were recorded from 15 leaves selected at random from 15 plants. The leaves were taken from upper, middle and lower portion of selected plants (Karar *et al*., 2013). The yield was recorded per plot of each variety in kg and converted into kilogram per acre. The data was compiled and subjected to statistical analysis.

***Red cotton bug (Dysdercus spp. (Hemiptera: Pyrrocoridae)*:** The red cotton bug is sucking pest which not only sucks the sap from green bolls but also stain the lint. The population of red cotton bug was recorded from 10 plants per plot and finally the average population of the pest per plant basis was taken out.

Cotton mealy bug (Phenacoccus solenopsis Tinsley (Sternorrhyncha: Pseudococcidae): The cotton mealy bug is also another sucking pest which attacks the plants in patches. The population was recorded from 10 cm twigs of 10 randomly selected plants per plot. Average population was calculated per plant.

Cotton leaf curl virus: The incidence of cotton leaf curl virus (CLCuV) can be calculated by counting all healthy and affected plants/plot throughout the season. The virus percentage was calculated through the formula

$$\text{Virus percentage} = \frac{\text{Virus affected plants}}{\text{Total number of plants}} \times 100$$

***Dusky cotton bug (Oxycarenus spp. (Hemiptera: Lygaeidae)*:** The dusky cotton bug attack on opened bolls which suck the sap from the immature seeds. The population of dusky cotton bug was recorded from 10 open bolls per plot and finally the population of the pest per boll basis was taken out.

Application of pesticides: The crop was sprayed with recommended insecticides and dose when the population of the sucking pest increase above the ETL level.

Statistical analysis: The data were subjected to analysis of variance (ANOVA) using Statistix software (release 8.1; Lawes Agricultural Trust Rothamsted Experimental Station, Rothamsted, UK). The means were separated by Tukey's HSD (Highest Significant Differences).

RESULTS

The data reveals that highly significant differences ($F=344.75$; df=4, 8; $P<0.01$; Table 1) were observed among different bt varieties of cotton regarding jassids population. The maximum number of jassids were recorded on IR5-NIBGE having 1.90 per leaf followed by Sitara-10M (1.30/leaf) and Bt-121 (1.27/leaf). The minimum population of jassids per leaf were recorded on IR4-NIBGE (0.40/leaf) which is statistically at par to Sitara-11M (0.55/leaf). Similarly significant differences ($F=534.21$; df=4, 8; $P<0.01$; Table 1) were observed among different bt cotton regarding whitefly population. The results reveal that whitefly

Table 1. Average population of sucking pests throughout the season

Varieties	Av. population of sucking pest per leaf			Av. Pop. of Red Cotton Bug per plant	Av. Pop. of Cotton Mealy Bug per 10 cm branch
	Jassids	Whitefly	Thrips		
IR4-NIBGE	0.40±0.01 c	2.99±0.01 d	1.23± 0.08a	3.38± 0.01a	0.00±0.00
IR5-NIBGE	1.90±0.03 a	8.56±0.02 a	1.19±0.01 a	0.00±0.00 e	0.00±0.00
BT-121	1.27±0.01 b	7.21±0.09 b	0.63±0.01 bc	2.40±0.03 b	0.00±0.00
Sitara -10M	1.30±0.01 b	7.36±0.10 b	0.39±0.01 c	0.70±0.09 d	0.00±0.00
Sitara -11M	0.55±0.00 c	6.03±0.01c	0.83±0.01 b	1.12±0.01 c	0.00±0.00
Tukey's HSD Value at 0.05%	0.16	0.45	0.31	0.37	

Means sharing similar letters are not significantly different by Tukey's HSD at P = 0.05,
HSD = Highest Significant Difference Value, * = Significant at $P \leq 0.05$, ** = Significant at $P \leq 0.01$.

population per leaf was more on IR5-NIBGE having 8.56 population per leaf followed by Sitara-10M (7.36/leaf) and Bt-121 (7.21/leaf). The minimum population (2.99 per leaf) of whitefly was found on IR4-NIBGE. Whereas Sitara-11M having 6.03 whitefly /leaf. Regarding thrips, the infestation was very low i.e. 0.39 to 1.23 per leaf was recorded on cotton varieties under study during the season. Regarding population of Red Cotton Bug (RCB) significantly differences (F=317.95; df=4, 8; P<0.01; Table 1) were found among varieties. More RCB 3.38/plant was recorded on IR4-NIBGE followed by Bt.121, Sitara-11M, Sitara-10M having 2.40, 1.12 and 0.70 red cotton bugs per plant. No population of RCB was recorded on variety IR5-NIBGE during the season.

The data regarding attack of bollworms on Bt cotton (Table 2), it was found that only Bt. 121 variety showed spotted bollworm attack, i.e. 4.12 per plant while all other varieties having zero population of spotted, American and pink bollworms.

The statistically more population of Dusky Cotton Bug (DCB) was recorded on variety Bt-121 having 5.54 individuals per open boll followed by Sitara-11M, Sitara-10M, IR4-NIBGE having 4.48, 3.22, 2.45 DCB individuals/open boll and the minimum individuals were observed on IR5-NIBGE (2.02/open boll). Similar trend of population was recorded on other dates (Fig. 1).

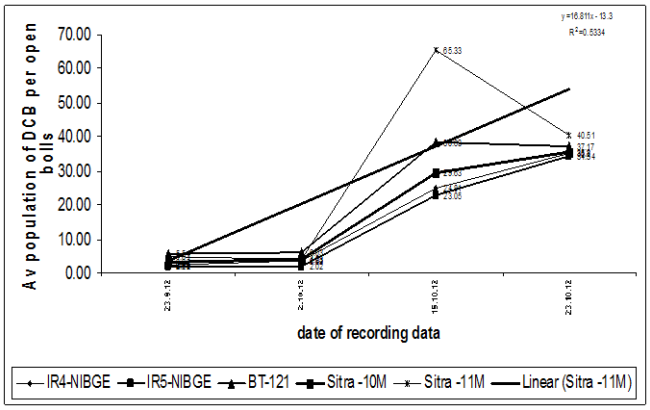

Figure 1. Population of DCB on different varieties of transgenic cotton

Regarding average yield per acre (Fig. 2) the statistically maximum yield per acre was obtained from the variety Bt-121 i.e. 1852 kg /acre followed by IR5-NIBGE, Sitara-11M , Sitara-10M with 1584, 1503, 1466 kg per acre whereas the lowest yield was obtained in the variety IR4-NIBGE, i.e.982 kg per acre under similar condition.

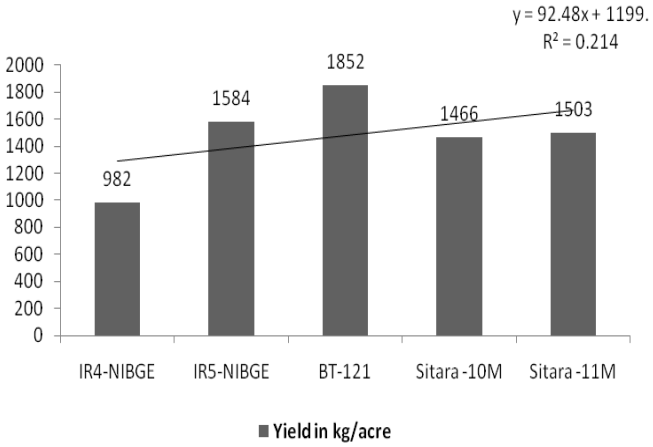

Figure 2. Average yield in kg per acre of different cotton genotypes

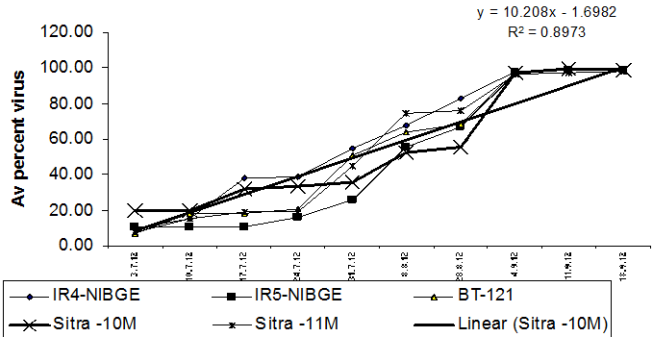

Figure 3. Virus incidence regarding different dates of observations

The incidence of CLCuV was 19.63% on Sitara-10M on the first week of July followed by IR5-NIBGE and IR4-NIBGE with 10.33 and 9.64% CLCV, respectively. Maximum level of tolerance was shown by the variety Bt-121 (6.74%) which

Table 2. Average population of bollworms per plant throughout the season

Varieties	Average population of bollworms per plant		
	***Earias* spp.**	***Heliothis armigera***	***Pectinophora gossypiella***
IR4-NIBGE	0.00±0.00	0.00±0.00	0.00±0.00
IR5-NIBGE	0.00±0.00	0.00±0.00	0.00±0.00
BT-121	4.12±0.06	0.00±0.00	0.00±0.00
Sitara -10M	0.00±0.00	0.00±0.00	0.00±0.00
Sitara -11M	0.00±0.00	0.00±0.00	0.00±0.00

is statistically similar to Sitara-11M having 7.48%. Whereas on 2nd week of July the incidence of virus was 19.72% on Sitara-10M followed by Bt-121, IR4-NIBGE, Sitara-11M having 18.11, 15.56, 15.13% and low level of virus was shown by the variety IR5-NIBGE having 10.46%. On 3rd week of July IR4-NIBGE showed maximum virus percent with 37.65% as compared to all other varieties under study followed by Sitara-10M, Sitara-11M, Bt-121 with 31.67, 18.67, 18.21% and the maximum level of tolerance was shown by the variety IR5-NIBGE having 10.54% virus. IR4-NIBGE with 38.41% virus was the most susceptible variety to virus during 4th week of July followed by Sitara-10M, Bt-121, Sitara-11M, 33.72, 20.18, 19.23% and low virus was shown by the variety IR5-NIBGE (15.79%). On last week of August statistically maximum incidence of virus was 54.79% on variety IR4-NIBGE followed by Bt-121, Sitara-11M, Sitara-10M with 50.60, 44.84, 35.84%, and less virus was shown by the variety IR5-NIBGE (25.88%). The maximum virus percentage was on Sitara-11M (74.29%) followed by IR4-NIBGE, Bt-121, IR5-NIBGE with 67.81, 64.14, 55.56%, respectively and minimum virus was shown by the variety Sitara-10M (52.21%) on 2nd of August. Variety IR4-NIBGE with 82.84% virus was the most susceptible during 4th week of August followed by Sitara-11M (75.69%), Bt-121 (68.71%), IR5-NIBGE (66.59%) and less virus was shown by the variety Sitara-10M (55.76%). On 1st week of September all the varieties under study were statistically at par to each other as there was no significant difference in the incidence of virus, i.e. 96.33 to 99.83.

DISCUSSION

Host plant resistance is a major part of an Integrated Pest Management program that protects the crop by making it less suitable for insect pests. It is chief management tact's through which one can easily overcome the insect pest with smaller quantity of insecticides. It is not only cost-effective but also safe for the atmosphere as reported by Pedigo (1989) and, Khan and Saxana (1998). An effective resistant variety can be considered those which maintain pest population below damage threshold (Aslam *et al*., 2004) and offer an economical preventive measure which compatible with other methods of pest control (Chauhadry and Arshad, 1989). Our results suggest that there is a variation regarding attack of insect pest complex. More jassids and whitefly population per leaf was observed on cultivars 'IR5-NIBGE' as compared with other cultivars. Low population of jassids per leaf was recorded on 'IR4-NIBGE'. Regarding thrips it is noted that the more population of thrips infestation was recorded on 'IR4-NIBGE' whereas the less population of thrips was found on 'SITARA-10M'. The red cotton bug (RCB) was more on 'IR4-NIBGE' as compared with other cultivars. The less RCB infestation was found on 'IR5-NIBGE'. The results are inconformity with that of Ali *et al*. (1999), Fairbanks *et al*. (2000), Nath *et al*. (2000) and Shad *et al.* (2001) who reported that variations of resistance levels is different among the various cotton genotypes against sucking pests complex. Whereas Shad *et al.* (2001) recorded population of sucking pests on four cotton varieties *viz.* 'Karishma', 'CIM-443', 'CIM-448', 'BH-136' and 'BH-637' and reported that 'CIM-443' was the most susceptible to thrips with 20.24/leaf and resistant to jassids having 0.74 jassids/leaf whereas 'BH-136' had higher whitefly attack (12.39/leaf). Amjad *et al*. (2009) worked on different cotton cultivars and screened out five cultivars of cotton *viz.*, 'FH-682', 'NIAB-78', 'FH-634', 'FS-628' and 'FH-643' which showed resistance against whitefly (*Bemisia tabaci* Genn.), jassids (*Amrasca devastans* Dist.) and aphid (*Aphis gossypii* Glov.) and found that 'FH-634' was most resistant to the sucking pest complex where as 'FH-682' was found to be most resistant to jassids. 'FS-628' showed maximum susceptibility to whitefly infestation. Shahid *et al*. (2012) screened out twenty advanced genotypes of cotton for resistance against thrips (*Thrips tabaci*) and reported that the variety 'FH-118' exhibited maximum resistance to the attack of thrips followed by 'GN-2085' where as varieties 'FH-177', 'FH-114' and 'FH-179' were found to be most susceptible and the remaining varieties proved to be tolerant against thrips population. In case of bollworms spotted bollworms were recorded only on 'Bt. 121' whereas zero population was recorded on all other Bt. cultivars. The reasons could be that there may be some mixing of non Bt. cotton seed in Bt. cotton varieties. The results are similar to Karar *et al*. (2013) who reported that Bt. cultivars are still free from the attack of bollworms; the presence of bollworms might be due to mixture of Bt. and Non Bt. cotton seeds. The population of DCB remain low in early season and high in the mid of Oct. The reasons could be the best time of breeding of DCB and availability of more opened bolls during such period. More yields per acre were obtained from 'Bt. 121' and low yield was recorded from 'IR4-NIBGE' under similar condition. The virus percentage was less in the beginning of the crop and increase with the passage of time under normal dates of sowing. The results can be compared with Karar *et al.* (2013) who reported that March sown crop has less than 1% virus as compared with normal and late sown cotton crop. Therefore, it is pre requisite to understand the behaviour of host plant and the effect of its various morphological characters for developing a viable pest management strategy. A comparison of the present findings with those already completed by Kim (1985), Malik and Nandal (1986), Sharipova (1987), Dhawan *et al.* (1990), Rao *et al*. (1991), Ali and Ali (1993), Tomar and Rana (1994), Arif *et al*. (2004), Aheer *et al*. (2006), Ali and Aheer (2007) etc. on the comparative resistance of cotton varieties to the insect pests of cotton was however not possible in precise terms because of their differences in the varietal/pest combination tried by them.

As such, the present efforts were definitely a new addition to the previous fund of knowledge.

Conclusions: Our results suggest that IR5-NIBGE cotton genotype is susceptible to most serious pest jassids and whitefly, whereas IR4-NIBGE and Sitara-11M are comparatively resistant. So IR4-NIBGE and Sitara-11M varieties can be included in IPM programme for the management of these voracious pests of cotton.

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