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RESPONSE OF BT COTTON GENOTYPES TO THE INFESTATION OF SUCKING AND BOLLWORM PESTS WITH RESPECT TO DIFFERENT PLANTING DATES

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ABSTRACT

Change in sowing time of crops is one of the important tools of integrated pest management that helps to escape or reduce the attack of certain insect pests. The present experiment was designed to evaluate the effect of three different sowing times *viz.* early (April), medium (May), and late (June) on the performance of five transgenic cotton genotypes ((IR-443, IR FH-901, IR-448, IR NIBGE-1 and IR-1513) against sucking and bollworm pests. The results revealed that the early sown (April) genotypes rendered higher jassid infestation compared to medium (May) and late sown (June) genotypes. The highest incidence of thrips and whiteflies was recorded on the late sown genotypes followed by medium sown genotypes. Bollworms (Pink and spotted) infestation did not reach to the Economic Threshold Level (ETL) in any of the early, medium or late sown genotypes, however, the late sown genotypes showed the highest bollworms occurrence. Significantly higher yield (kg/ha) was produced by the early sown (April) genotypes followed by medium sowing (May). Among all the transgenic cotton genotypes tested in early, medium and late sowing dates, IR-443 proved to be significantly the most efficient genotype in term of showing the lowest pest incidence and highest cotton yield followed by IR-FH-901. The studies manifested that sowing of the latter two cotton genotypes in April (early sowing) could be very effective to deal with major pest population and getting higher yield.

Keywords: Bt cotton, sowing time, sucking complex, bollworms, infestation

INTRODUCTION

Cotton (*Gossypium hirsutum* L.), one of the key crops of Pakistan, is responsible for the livelihood of a huge number of people across the country (Ahmad, 2003). This fiber crop is cultivated on about 2699 thousand hectares area with an average yield of 752 kg ha^{-1} and lint production of 11935 thousand bales. Cotton products contributes about 5.5% to the value added in agriculture and approximately 1% to gross domestic product (GOP, 2018). Irrespective of the fact that Pakistan holds fourth position regarding cotton production, it lies far behind in term of average per hectare yield of cotton crop compared to other major cotton producing countries (Khan *et al.,* 2011). Among other prominent constraints in cotton production, insect pest attack is one of the leading causes. Cotton crop is infested by a number of different sucking and chewing pests both at vegetative and reproductive stages (Yunus *et al.,* 1980). *Thrips tabaci* (Lindeman), aphids, *Aphis gossypii* (Glover), whitefly, *Bemisia tabaci* (Gennadius), red cotton bug, *Dysdercus koenigii* (Fabricius) and dusky cotton bug, *Oxycaranus hayalinipennis* (Costa) are considered major sucking pests of cotton (Ahmad *et al.,* 2002). Among the chewing pests, pink bollworm *Pectinophora gossypiella* (Saunders), American bollworm *Helicoverpa armigera* (Hubner), spotted bollworm *Earias vittella* (Fabricius) and Army worm, *Spodoptera litura* (Fab) are the major menaces (Khan *et al.,* 2011).

These insect pests are usually suppressed by the application of broad spectrum pesticides that are continuously deteriorating the environment (Hassan, 1992). Many of the synthetic pesticides are interfering with the endocrine system of living organism thereby leading to infertility, carcinogenesis and mutagenesis (Dinham, 1993). The widespread application of toxic chemicals to most agro-ecosystems provide a way to the dissemination of these poisons to soil, aquifers and water systems of most agricultural habitat. In the long term this could cause colossal losses to human health, wildlife and the environment. Consequently, there is a dire need to substitute pesticides with the use of other pest control methods that are environmentally safe and economical (Mohammad *et al.,*

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2010). The use of environmentally safe methods are usually incorporated in integrated pest management (IPM) where different control methods are used simultaneously or sequentially against a certain pest thereby reducing the need for pesticides (Shahid, 2003; Khan *et al.,* 2011).

One of the key tools of IPM is to slightly modify the sowing time so that to make the environment unfavorable for the pests. Appearance, population dynamics, infestation frequency of a pest and also crop yield are very much linked to the sowing time. Management of sowing time not only has healthy effect on crop growth, and yield but also positively influences pest management (Shahid, 2003). A slight modification in sowing time helps to escape/minimize pest attack by creating asynchrony between the pest and its host plant. However, Early or late planting may also render the environment unfavorable for the crop and may affect the crop yield (Ali *et al.,* 2009). There are a number of studies conducted on different dates of sowing of cotton by a various workers with a variety of results. Qayyum *et al.* (1990) reported that sowing of cotton crop on 15th April showed increased cotton yield apparently due to increase in fruiting bodies and branches. Cotton crop when sown in the month of May produced better yields than early sowing of April and late sowing of June under climatic conditions of Sindh (Khan *et al.,* 1988). Mithaiwala *et al.* (1975) reported that mid-May was the ideal seeding time under Gudu Barrage whereas very early or late sowing of cotton leads to limited yield. Similarly Shahid *et al.* (2014) documented higher pest incidence in early sown cotton genotypes whereas Ali *et al.* (2015) reported the lowest pest attack on early sown cotton. The recommended time for cotton sowing in central Sindh region is reported to be the first fortnight of May (Soomro *et al.*, 2001). Keeping in view the importance of sowing time of cotton for the management of different insect pests, the present studies were designed with the objective to evaluate the effect of different sowing dates of Bt cotton genotypes on the infestations of sucking pests and bollworms.

MATERIALS AND METHODS

To evaluate the effect of different sowing dates of transgenic cotton genotypes against sucking and bollworm pests, five Bt cotton genotypes *viz.* IR-443, IR FH-901, IR-448, IR NIBGE-1 and IR-151 were sown under field conditions on three different dates (13-04-2013, 13-05-2013 and 13-06-2013, respectively). Based on the month of sowing i.e. April, May and June, these different sowing dates were regarded as early, medium and late sowing, respectively. The experiment was replicated four times using Randomized Complete Block Design. Plot size of each experimental unit was 15 m x 10 m with a distance of 0.75 m between the rows and 0.30 m between the plants. All the varieties sown on different dates (early, medium and late) were given normal agronomic practices for raising the crop. No control measures were adapted for any of the pests during the crop-growing season even if the pest infestation approached to the economic threshold level (ETL). The data were regularly recorded on the population of different pests after each fortnightly interval throughout the cropping season. The populations of sucking insect pests *viz. A. devastans*, *T. tabaci* and *B. tabaci* were recorded early in the morning. Three leaves one each from top, middle and bottom of five randomly selected cotton plants were observed. This data were then transformed to per leaf basis. For recording bollworms infestation, buds, flowers were thoroughly observed and the bolls were dissected on five plants randomly selected in each replicate. Percent pest incidence of pink and spotted bollworm was calculated separately by using the following formula:

$$\text{Percent infestation} = \frac{\text{Number of damaged fruiting parts}}{\text{Total number of fruiting parts}} \times 10$$

The data recorded on sucking complex and bollworms from Bt cotton genotypes of each experimental unit with different sowing times were used to evaluate the relationship of pest incidence with sowing time. The same data also helped to assess level of resistance in transgenic cotton genotypes. Cotton yield from each plot of each respective genotypes was carefully recorded. The data were finally subjected to statistical analysis and means were compared by LSD test at 5% level of probability using computer software SPSS 2008.

RESULTS AND DISCUSSION

Bt cotton genotypes sown in April (early sowing)

The results revealed (Table 1) that the jassid infestation was above ETL in all genotypes sown early (April), however, the genotypes IR-443 was found to be the most efficient for holding reduced mean jassid population (2.81 ± 0.21/leaf). IR-FH-901, IR-448 and IR-1524 were found insignificantly different among each other where mean per leaf population of jassid was 3.26 ± 0.19,349 ± 0.16 and 3.50 ± 0.66 per leaf, respectively. IR-1513 exhibited higher susceptibility to jassid where maximum per leaf infestation of 3.96 ± 0.34 was observed. Population of thrips in IR-443 (3.51 ± 0.99) was statistically at par with that of IR-FH-901 (3.96 ± 1.64), but was significantly lower than all other transgenic cotton genotypes. IR-1513 proved to be the most susceptible where the highest per leaf thrips infestation of 5.13± 1.07 was recorded. The lowest per leaf whiteflies occurrence of 0.32 ± 0.01 was observed on IR-443 which was insignificantly different with IR-FH-901 (0.43 ± 0.10) and IR- 448 (0.50 ± 0.08). IR-1513 appeared to be more susceptible to whiteflies attack where highest infestation of 0.80 ± 0.06 per leaf was recorded. No pink bollworm infestation (%) was observed on any of the genotypes except IR-1513 (0.9 ± 0.01). The lowest percent infestation of spotted bollworm was observed on IR-443 (0.21 ± 0.04) followed by IR-FH-901 (0.66 ± 0.06) whereas the highest was investigated on IR-1513 (1.08 ± 0.06). The cotton yield was related with the degree of pest infestation, and yield increased with decrease in infestation level. Maximum yield of 4766.6 ± 201.45 kg/ha was recorded from genotype IR-443 followed by IR-FH-901 (4373.3 ± 189.23). IR-1513 rendered heavy pest attack and thereby produced lowest yield of 3500 ± 122.74 kg/ha (Fig. 1).

Table 1.
Response of five Bt cotton genotypes sown in April (early sowing**)** against sucking and bollworm complexes.

Genotypes	jassid/leaf	thrips/leaf	whiteflie /leaf	pink bollworm (%)	spotted bollworm (%)
IR-443	2.81 ± 0.21 C	3.51 ± 0.99 C	0.32 ± 0.01 C	0.00 ± 0.00 A	0.21 ± 0.04 B
IR-FH-901	3.26 ± 0.19 B	3.96 ± 1.64 BC	0.43 ± 0.10 BC	0.00 ± 0.00 A	0.66 ± 0.06 AB
IR-448	3.49 ± 0.16 B	4.29 ± 1.69 B	0.50 ± 0.08 BC	0.00 ± 0.00 A	0.84 ± 0.02 A
IR-1524	3.50 ± 0.66 B	4.83 ± 1.22 A	0.55 ± 0.01 B	0.00 ± 0.00 A	0.89 ± 0.02 A
IR-1513	3.96 ± 0.34 A	5.13 ± 1.07 A	0.80 ± 0.06 A	0.09 ± 0.01 A	1.08 ± 0.06 A
LSD Value	0.32	0.53	0.18	0.14	0.54

Means within a column followed by different letters are significantly different (P<0.05)

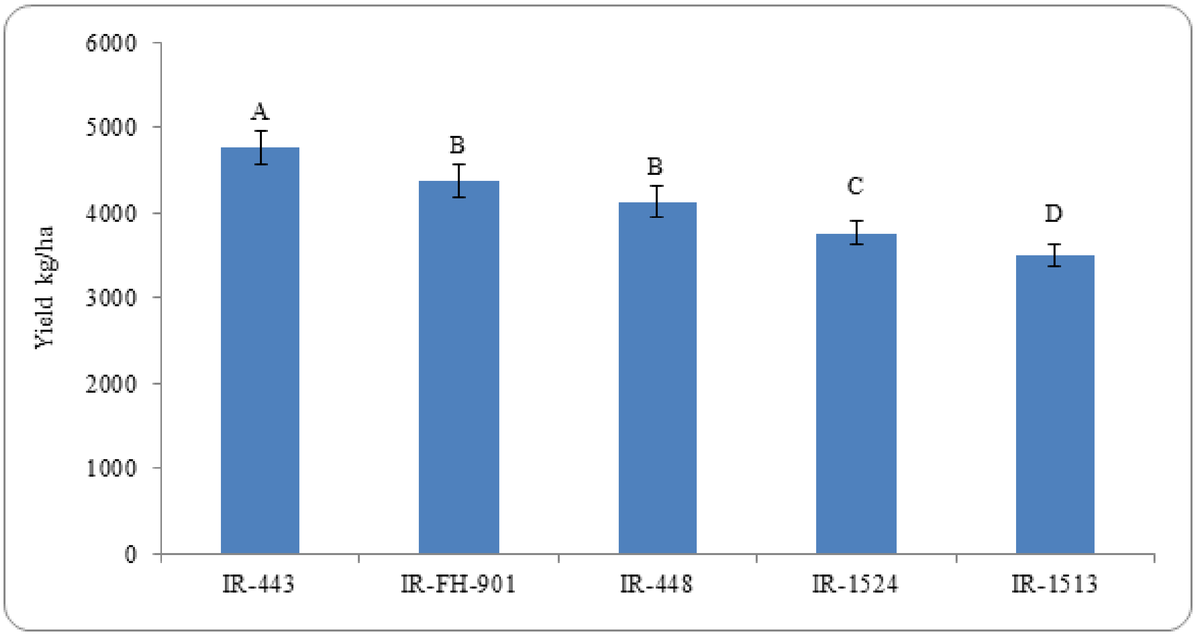

Fig. 1
Yield (kg/ha) of different Bt cotton genotypes sown in April (early sowing).

Bt cotton genotypes sown in May (medium sowing)

Results of transgenic cotton genotypes sown in May (medium sowing) are given in table 2. Genotype IR-443 exhibited the lowest per leaf jassid infestation (1.22 ± 0.08) followed by IR-FH-901 (1.27 ± 1.27) throughout the cropping season. IR-1513 displayed more jassid susceptibility where maximum jassid per leaf of 1.81 ± 0.01 were observed. Significantly higher per leaf thrips infestation (7.33 ± 2.23) was also observed on IR-1513 compared to all other genotypes tested whereas the lowest was recorded on genotype IR-443 (5.68 ± 1.13) followed by IR-FH-901 (5.75 ± 1.53). Whiteflies population varied significantly among different genotypes. IR-1513 rendered a maximum number of whiteflies (0.94 ± 0.02) followed by IR-1524 (0.72 ± 0.01) compared to all other genotypes. IR-443 appeared most tolerant genotype where the lowest whiteflies attack (0.52 ± 0.04) was recorded. Percent infestation by pink bollworm occurred below ETL in all transgenic cotton however, the highest (0.57 ± 0.05) was recorded in IR-1513 followed by IR-1524 (0.41 ± 0.01). The lowest infestation was recorded in IR-443 (0.25 ± 0.01). The same pattern was true for spotted bollworm attack (%) where highest was recorded in IR-1513 (1.78 ± 0.12) followed by IR-1524 (0.90 ± 0.06). IR-443 again proved more tolerant rendering lowest percent spotted bollworm infestation of 0.60 ± 0.01 (Table 2). Results confirmed that the best yielded genotype was IR-443 having a yield of 3478.21 ± 112.45 kg/ha. IR FH-901, IR-448 and IR 1524 contributed in similar sequence giving 3200.15 ± 98.79, 2886.43 ± 88.38 and 2788.43 ± 87.11kg yield per hectare, respectively. The increase in yield in genotypes IR-443, IR FH-901 and IR-448 was their contributions to hold lower sucking pests populations and higher genetic yield potential. IR-1513 gave the lowest yield of 2631.43 ± 87.11 kg/ha as compared to other genotypes tested, which was significant statistically. This genotype showed its poorest plant stand due to the infestation of sucking complex resultantly, the lowest yield was obtained (Fig. 2).

Table 2.
Response of five Bt cotton varieties sown in May (medium sowing) against sucking and bollworm complexes

Genotypes	jassid/leaf	thrips/leaf	whiteflies/leaf	pink bollworm (%)	spotted bollworm (%)
IR-443	1.22 ± 0.08 B	5.68 ± 1.13 B	0.52 ± 0.04 C	0.25 ± 0.01 B	0.60 ± 0.01 B
IR-FH-901	1.27 ± 0.07 B	5.75 ± 1.53 B	0.64 ± 0.03 BC	0.32 ± 0.02 AB	0.67 ± 0.01 AB
IR-448	1.62 ± 0.03 A	6.29 ± 1.04 B	0.69 ± 0.01 B	0.30 ± 0.03 AB	0.84 ± 0.02 AB
IR-1524	1.69 ± 0.02 A	6.28 ± 1.18 B	0.72 ± 0.01 B	0.41 ± 0.01 AB	0.90 ± 0.06 AB
IR-1513	1.81 ± 0.01 A	7.33 ± 2.23 A	0.94 ± 0.02 A	0.57 ± 0.05 A	1.78 ± 0.12 A
LSD Value	0.20	0.63	0.15	0.28	1.05

Means within a column followed by different letters are significantly different (P<0.05).

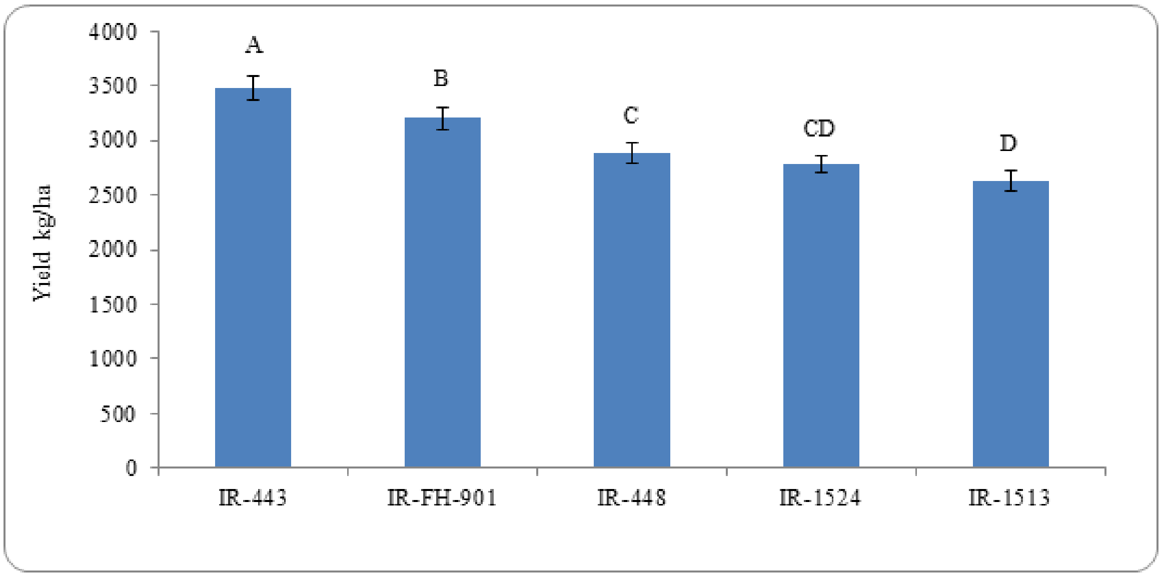

Fig. 2
Yield (kg/ha) of different Bt cotton genotypes sown in May (medium sowing).

Bt cotton genotypes sown in June (late sowing)

Data regarding infestation of sucking and bollworm pests on Bt cotton genotypes sown in June (late sowing) is presented in table-3. Results revealed that IR-443 rendered significantly the lowest jassid infestation (0.78 ± 0.07) followed by IR-FH-901 (1.27 ± 0.08). Maximum infestation was recorded on IR-1513 (2.53 ± 0.04) which was statistically higher compared to all other genotypes. The lowest per leaf infestation of thrips was investigated on IR-443 (6.06 ± 1.14). In the rest of the genotypes, it was statistically at par except IR-1513 which proved most susceptible showing significantly higher attack (11.73 ± 3.18). IR-443 was again the least preferred genotype regarding whiteflies infestation where lowest population (0.56 ± 0.01) was recorded followed by IR-FH-901 (0.81 ± 0.08). IR-1513 appeared to be the most susceptible rendering maximum per leaf population of 1.19 ± 0.16. Percent pink bollworm attack was found insignificantly different in all tested genotypes, however, lowest was observed on IR-443 (1.01 ± 0.16) and highest on IR-1513 (1.78 ± 0.07). The population of spotted bollworm varied significantly, lowest percent infestation was recorded on IR-443 (1.01 ± 0.08) followed by IR-FH-901(1.09 ± 0.09) whereas highest was observed on IR-1513 (3.70 ± 0.96) (Table 3). IR-443 proved to be the best in term of giving significantly a higher yield of 2566.58 ± 116.45 kg/ha followed by IR-FH-901 (2266.15 ± 87.68). IR-1513 performed poorly showing a lowest yield of 1300.86 ± 44.47 kg /ha (Fig. 3).

Table 3.
Response of five Bt cotton varieties sown in June (late sowing) against sucking and bollworm complexes.

Genotypes	jassid/leaf	thrips/leaf	whiteflies/leaf	pink bollworm (%)	spotted bollworm (%)
IR-443	0.78 ± 0.07 D	6.06 ± 1.14 C	0.56 ± 0.01 C	1.01 ± 0.16 A	1.01 ± 0.08 B
IR-FH-901	1.27 ± 0.08 C	8.97 ± 2.17 B	0.81 ± 0.08 BC	1.09 ± 0.19 A	1.09 ± 0.09 B
IR-448	1.58 ± 0.01BC	9.59 ± 1.81 B	0.87 ± 0.04 B	1.25 ± 0.06 A	2.67 ± 0.56 A
IR-1524	1.89 ± 0.07 B	9.60 ± 1.66 B	0.92 ± 0.09 AB	1.25 ± 0.15 A	2.89 ± 0.81 A
IR-1513	2.53 ± 0.04 A	11.73 ± 3.18 A	1.19 ± 0.16 A	1.78 ± 0.07 A	3.70 ± 0.96 A
LSD value	0.46	1.75	0.27	0.85	1.53

Means within a column followed by different letters are significantly different (P<0.05).

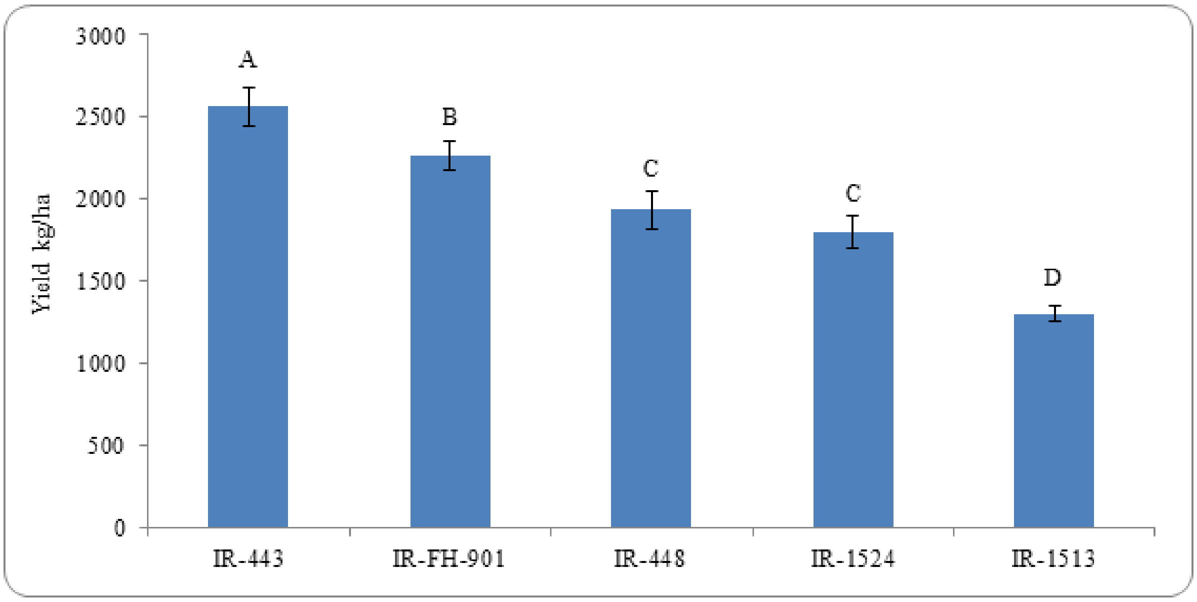

Fig. 3.
Yield (kg/ha) of different Bt cotton genotypes sown in Jun (late sowing).

Pooled data of Bt cotton genotypes (early, medium and late sowing)

Pooled data (Table 4) of transgenic cotton genotypes sown in different dates revealed that the genotypes sown early attracted higher number of jassid (3.40 ± 0.18) compared to medium (1.52 ± 0.68) and late sowing (1.61 ± 0.19). The highest thrips and whiteflies incidence (9.19 ± 2.11 & 0.87 ± 0.17, respectively) was noted in late sown genotypes followed by medium sowing whereas lowest population was observed on early sown Bt cotton genotypes (4.34 ± 1.81&0.52 ± 0.1, respectively). Pink and spotted bollworm attack was found below ETL in all early, medium and late sown genotypes, however, highest was recorded in the late sown whereas lowest in the early sown genotypes. Significantly higher yield (4107.6 ± 210.12 kg/ha) was recorded from genotypes sown early (April) followed by medium sowing (May) (2996.88 ± 188.14 kg/ha) as given in Fig. 4.

Table 4.
Pooled data of five Bt cotton genotypes (early, medium and late sowing).

Sowing time	jassid/leaf	thrips/leaf	whiteflies /leaf	pink bollworm (%)	spotted bollworm (%)
Early	3.40 ± 0.18 A	4.34 ± 1.81 C	0.52 ± 0.11 C	0.01 ± 0.00 C	0.73 ± 0.11 B
Medium	1.52 ± 0.68 B	6.26 ± 1.22 B	0.70 ± 0.15 B	0.37 ± 0.08 B	0.95 ± 0.22 B
Late	1.61 ± 0.19 B	9.19 ± 2.11 A	0.87 ± 0.17 A	1.27 ± 0.27 A	2.27 ± 1.04 A
LSD value	0.65	1.06	0.07	0.10	0.95

Means within a column followed by different letters are significantly different (P<0.05).

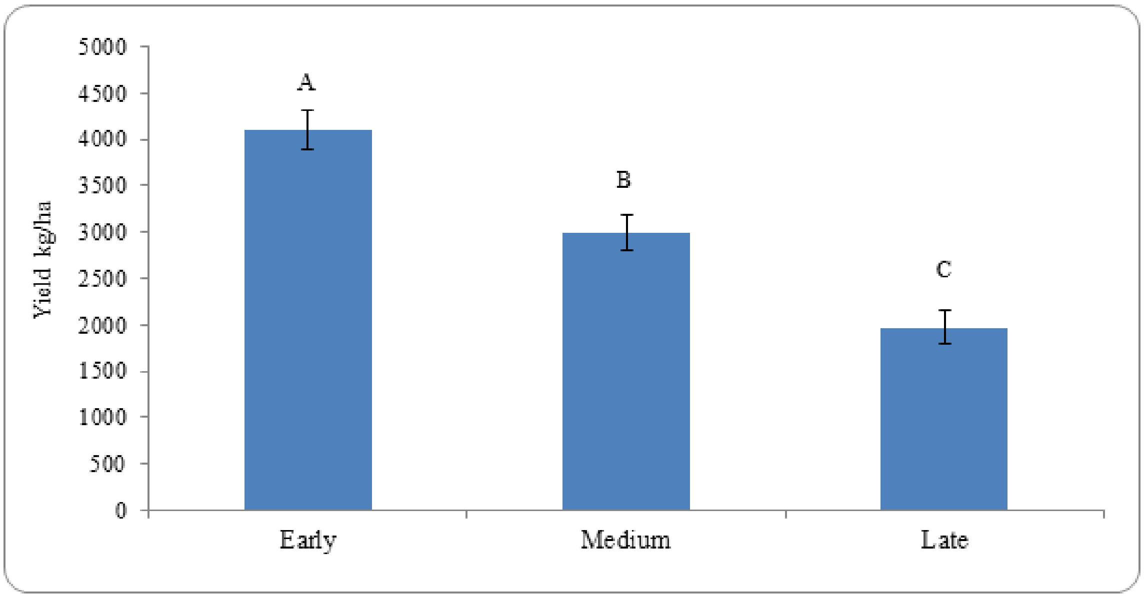

Fig. 4.
Combined yield (kg/ha) obtained from early, medium and late sown Bt cotton genotypes.

The infestation of different insect pests varied greatly on all the tested genotypes sown in different dates and so was the yield. The sucking pests appeared to be more prominent part of pest complex in all tested transgenic cotton varieties whereas bollworms infestation was below ETL except for spotted bollworm in some of the late sown genotypes. Low bollworm infestation in Bt cotton genotypes in all planting dates is attributed to the expression of insecticidal protein derived from *Bacillus thuringiensis* against target Lepidopterous pests. However it has no effect on sucking pests and that is why lacks resistance against them (Sharma & Pampapathy, 2006). Men *et al.* (2003); Bambawale *et al.* (2004) revealed that transgenic cotton had no impact on the sucking pest population. Similarly previous field studies by Abro *et al.* (2004) and Naveen *et al.* (2007) showed higher infestation of thrips, jassid and whiteflies in Bt cotton as compared to conventional cotton.

In the present studies, Bt cotton genotypes sown in April (early sowing) were least preferred by different insect pests except jassid which appeared abundantly. The transgenic cotton genotypes sown in June (late sowing) performed very poorly showing maximum insect pests' attack thereby giving lower cotton yields. Among different Bt cotton genotypes, IR-443 appeared to be the most tolerant genotype on all planting dates exhibiting least pest infestation and higher yield; this was followed by IR-FH-901 (Khan *et al.,* 2011). A number of research studies have been undertaken by various workers on planting dates of cotton under diverse climatic conditions of different areas. Feng *et al.* (2003) revealed that late sowing of cotton in June attract a significantly higher number of bollworms compared to early sowing which is in agreement to the present research findings. Qayyum *et al.* (1996) experimented different dates of sowing of cotton in climatic conditions of Tandojam (Sindh) and found that early sowing of cotton genotypes gave significantly higher cotton yield compared to late sowing which is in agreement with the conclusion of our study. Shahid *et al.* (2014) revealed higher pest attack in early sown cotton genotypes whereas contrary to this Ali *et al.* (2015) found the highest pest infestation in late sown genotypes. It is important to mention that apart from pest incidence, climatic conditions required for boll opening are affected by different sowing times which also lead to increase or decrease seed cotton yield (Ali *et al.,* 2009).The accessibility of plants to more optimum conditions allow the plants to gain maximum growth thereby producing more number of bolls and hence the yield (Norfleet *et al.,* 1997). This factor may be one of the reasons of higher yield of early sown genotypes apart from pest infestation. Arshad *et al.* (2007) reported that early sown cotton produced 10% more flowers, 23% more open bolls and 18% more seed cotton yield compared to late sowing. Contrary to this, Bange *et al.* (2008) observed low cotton produce from early sown bollgard II cotton.

CONCLUSION

It can be concluded from the present research findings that all the genotypes sown early (April) produced significant results in term of least infestation by thrips, whiteflies and bollworms and higher cotton yield. Late sowing in June of cotton genotypes rendered heavy pest infestation which greatly affected the cotton yield. Among different Bt cotton genotypes tested, IR-443 proved to be the most efficient genotypes for holding reduced pest population and maximum cotton yield followed by IR-FH-901. The studies manifested that sowing of the latter two Bt cotton varieties/genotypes early i.e. in the fortnights of April could be very helpful to manage certain pest populations.

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