FROM CONVENTIONAL TO BT COTTON AND BOLLWORMS TO WHITEFLY: COTTON CULTIVATION UNDER THREAT IN NORTHERN INDIA

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Abstract

The Bt-cotton since its introduction in 2005 in North India has witnessed upsurge in sucking insect-pests every season. This may be attributed to decrease in insecticidal sprays in post-Bt era, susceptibility of the germplasm being introduced as cotton hybrids and the failure of existing spray technology to reach throughout the bushy cotton hybrids. The Bt-cotton received the first blow only two years after the introduction in the form of the outbreak of mealy bug in 2007. In 2010, there was heavy incidence of whitefly along with cotton leaf curl disease across Punjab. The big blow to cotton production has been reported in 2015 resulting in loss of nearly 50-60 % cotton across state. There has been a complete failure of the insecticides to manage the pest and 40-50 percent of the area under cotton was ploughed in the middle of the cotton season. The whitefly population remained far above ETL from July to September. The situation at the farmers' field was worse; the average population at 20 and 15 locations surveyed in July and August was 188.8 and 185.5 whiteflies per leaf, respectively. The population came down drastically down i.e.42.6 whiteflies per leaf in the end of September, however it maintained its ETL status during this period. Whitefly populations are largely regulated by the climatic factors such as temperature, rainfall and humidity. High temperature with high humidity has a positive correlation with the population build-up of this pest. The situation in 2015 was the most favourable for whitefly in terms of the high humidity which remained above 80 % from July till September. The paper discusses the current status of whitefly as pest of cotton and key factors for its outbreak in the state in context to pre and post Bt-cotton era.

Introduction

The insect-pest scenario has drastically changed with huge adoption of Bt-cotton (Dhawan et al 2008). When Bt-cotton was introduced in Northern India in 2005, the cotton was under the serious threat of bollworms. This state of art pest management technology rightly addressed the prevailing issues and was widely adopted by the farmers (Kranthi 2012). Post introduction, the sucking insect-pests were increasing every cotton season. This may be attributed to decrease in insecticidal sprays in post-Bt era, susceptibility of the germplasm being introduced as cotton hybrids and the failure of existing spray technology to reach throughout the bushy cotton hybrids. The Bt-cotton received the first blow only two years after the introduction in the form of outbreak of mealybug in 2007. The year experienced the overall heavy infestation of mealybug throughout the Northern India which forced farmers to spray indiscriminately to control the pest. However, the subsequent years i.e. 2008, 2009 and 2010 witnessed the miraculous decline in the bug population which may be accredited to large scale awareness and campaign programmes created across the state (Singh *et al* 2012). From 2010 onwards the whitefly has been on upsurge with population levels above ETL throughout the cropping season. Whitefly populations are largely regulated by the climatic factors such as temperature, rainfall and humidity. High temperature with high humidity has a positive correlation with the population build-up of this pest. Besides weather, inflow of susceptible genotypes, excessive use of nitrogenous fertilizers and insecticides or mixtures of insecticides and many other factors have played an important role in the population build-up of this notorious pest.

Methods

The insect population dynamics data collected under the All India Coordinated Cotton Improvement Project has been broadly divided into two phases. The pre Bt-cotton era i.e. 2001-02 to 2005-06 and post Bt-cotton era from 2006-07 onwards. Population of insect pests was recorded on non-Bt genotypes such Ganganagar Ageti, HS 6 and Bt genotypes RCH 134 Bt and RCH 134 BGII at weekly interval throughout the season starting from 25th standard meteorological week onwards which is the third week of June. The standard meteorological week starts from first week of January. The population of whitefly was recorded from three fully formed leaves from 20

cotton plants selected at random in a half acre plot. The incidence of CLCuD (cotton leaf curl disease) has been recorded from four different locations across Punjab state. The population of American bollworm *Helicoverpa armigera,* Spotted bollworm *Earias* sp. and *Spodoptera litura* was recorded per 5 plants. Population of Pink bollworm *Pectinophora gossypiella* PBW was recorded per 20 green bolls at 120, 135 and 150 DAS. Trap catch data was also recorded for *H. armigera, E. vittella, E. insulana, S. litura* and *P. gossypiella* using funnel pheromone traps, Helilure, Ervitlure, Erinlure, Spodolure and Pectinolure @ 1-2 traps/acre (PCI, India Ltd.) at weekly intervals. The daily weather data such as temperature, relative humidity, rainfall was obtained from the meteorology station installed at Regional Station, Faridkot.

Results

The bollworms' population before the introduction of Bt Cotton was the major concern among the farmers. The American bollworm *H. armigera* was the predominant among the three bollworms. Population of *Spodoptera* remained fluctuating, however it was not considered a major pest in pre-Bt era (data for bollworm and *Spodoptera* before introduction of Bt-cotton not presented). The havoc of bollworms was such that it threatened to wipe out the cotton cultivation from the northern part of India. The management of bollworms especially *H. armigera* seemed arduous as it had developed resistance to almost all the insecticides used for its control (Kranthi et al 2002). The farmers at an average made 15-20 sprays of different insecticides for the management of this bollworm complex. Bt cotton introduction gave the much needed relief as the bollworms' population reduced drastically. Interestingly, the adult male pheromone traps installed for monitoring of bollworms and *Spodoptera* presented a large variation in catch number per week. A drastic decrease in pink bollworm larvae has been observed over the years. The *H. armigera* and spotted bollworm larvae as well as adult male catches have been slightly increased over the years. The *Sopdoptera* catches have been fluctuating from very high to low over the years with no uniform trend. (Figs. 1-4)

In the years from 2006 to 2009, the whitefly population remained almost below ETL; however, the year 2010 besides being the hottest in the last decade also recorded the highest morning RH in the preceding five years (Fig 5). The whitefly population has been continuously on rise since 2010. On contrary, the whitefly population before the introduction of Bt-cotton remained low and it was above ETL only in 2001 (data not presented) throughout the growing season.

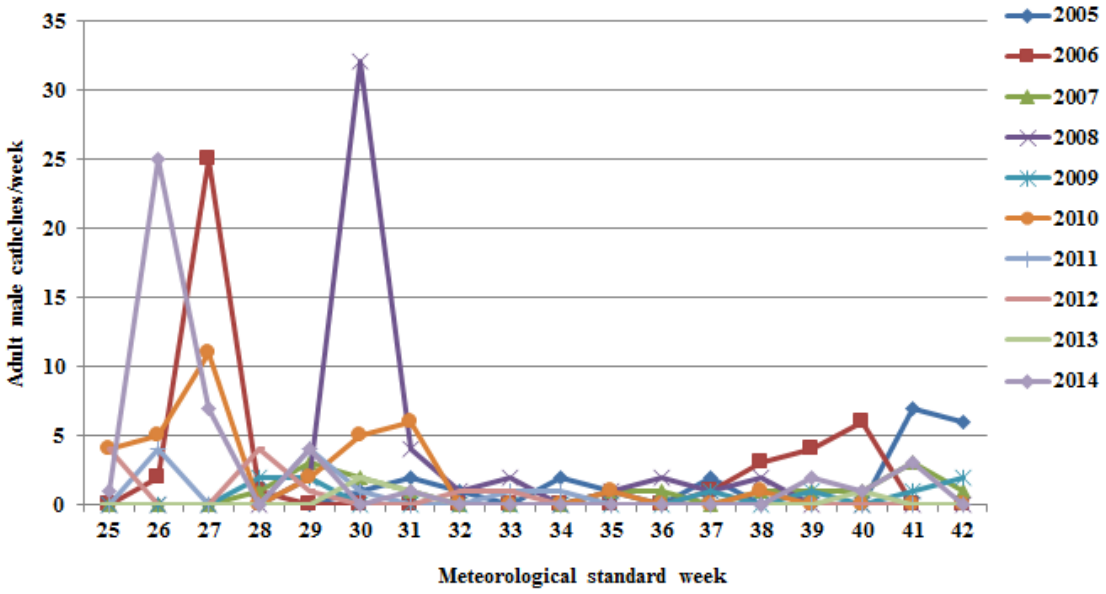

Fig 1. Pheromone catches/trap/week of *H. armigera* over the years

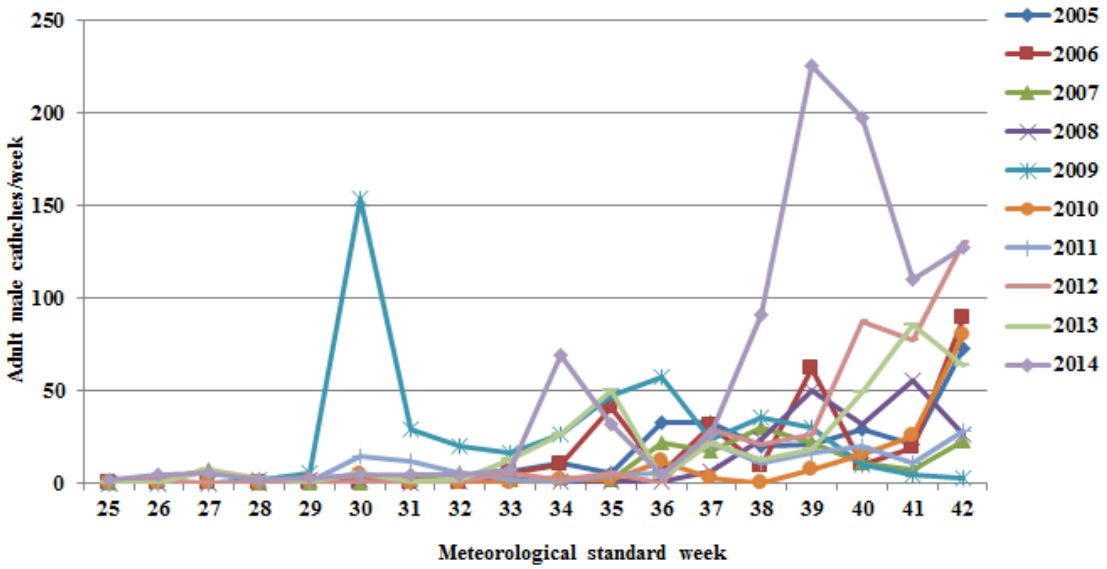

Fig 2. Pheromone catches/trap/week of *Earias* sp over the years

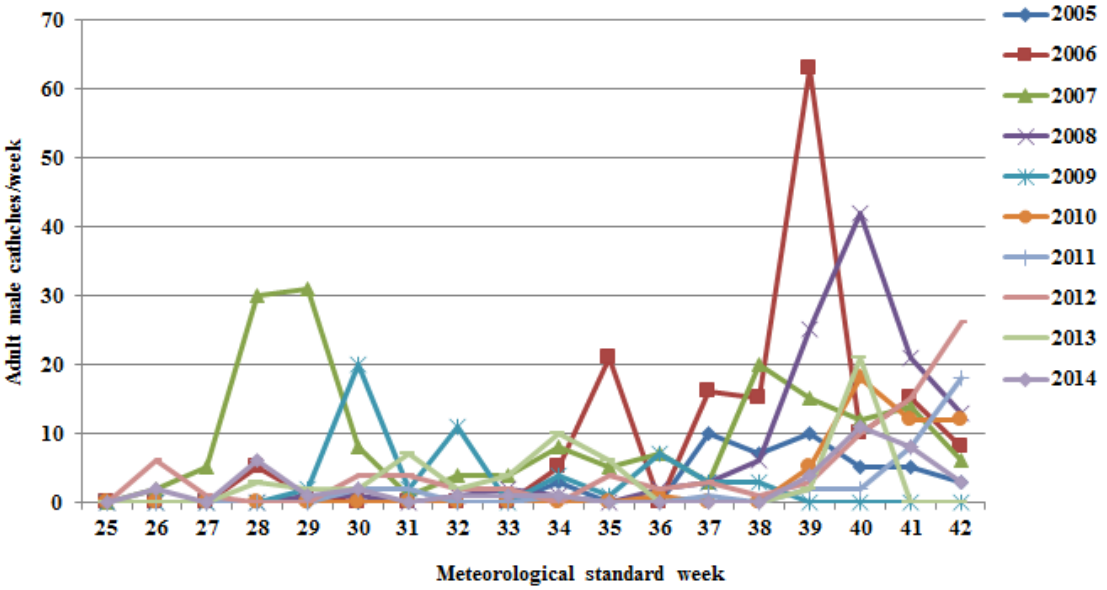

Fig 3. Pheromone catches/trap/week of *Pectinophora gossypiella* over the years

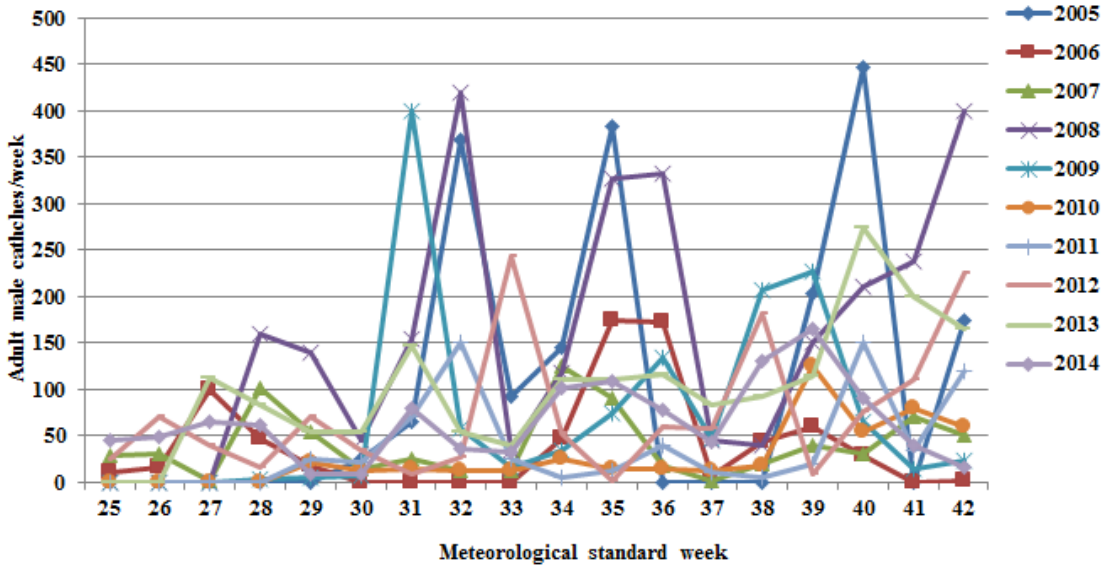

Fig 4. Pheromone catches/trap/week of *Spodoptera* over the years

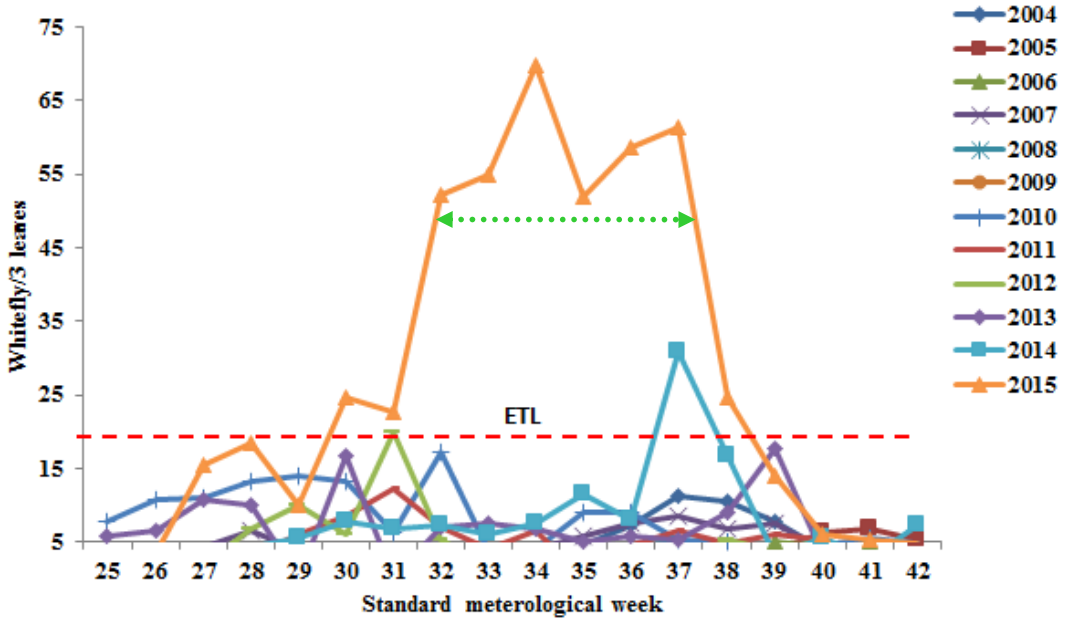

Fig 5. Population fluctuations of whitefly over the years after the introduction of Bt-cotton

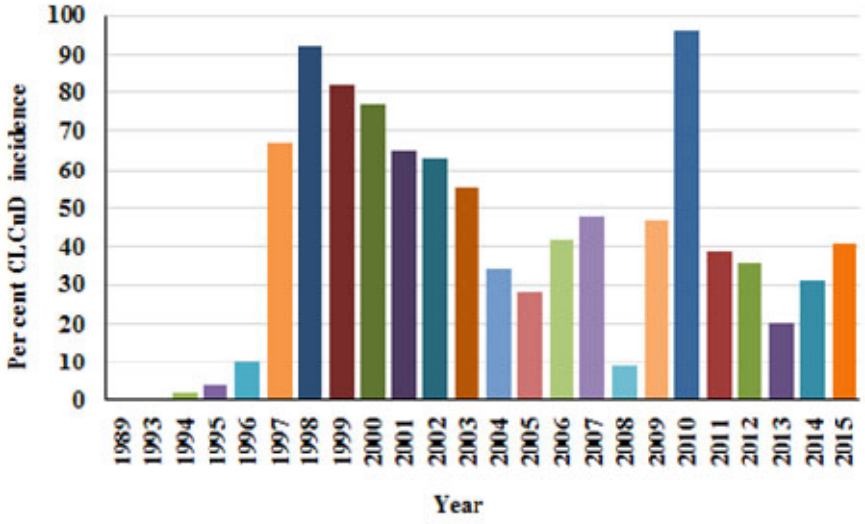

Fig 6. Incidence of CLCuD over the years in pre and post Bt- cotton period

In 2010, the population appeared early in the season and remained high till August. In 2011 there was a slight peak of whitefly population in July and August, while the peak appeared early in 2012 and crossed ETL in the middle of season. In 2013, the population remained high throughout the season with two early season peaks and one peak appearing in late September. In 2014, the incidence started in late July and crossed ETL in middle of September. The big blow to cotton occurred in 2015 with population reaching far above ETL almost throughout the season. The whitefly population started building up in the 26th standard meteorological week and remained above ETL till end of September. The situation at the farmers' field was worse where the average population at 20 locations surveyed in July and August (15 locations) was 188.8 and 185.5 whiteflies per three leaves respectively. The population came down drastically i.e.42.6 whiteflies per three leaves in the end of September (average of 25 locations) in the cotton growing region of Punjab, however it maintained its ETL status during this period. The situation in 2015 was most favourable for whitefly in terms of the high humidity which remained above 80 % from July till September. This might be the key factor for the outbreak of this pest in 2015.

The incidence of the CLCuD has been fluctuating for the many past years (Fig 6). The CLCuD incidence does not show any correlation with the whitefly incidence. The leaf curl incidence and intensity in 2015 was comparatively less compared to 2010 when the whitefly numbers were lower compared to that in 2015.

Summary

The bollworms population in Punjab has been rightly checked by the Bt cotton. There has been a drastic decrease in the pheromone trap catches of all bollworms after the introduction of Bt-cotton. This may be due to the huge selection pressure caused by the Cry toxins. However, subsequent increase in the pheromone trap catches of all bollworms except pink bollworm observed over the years may be an indicative that the pest population is trying to adjust in the Bt-cotton environment on other alternate crops. The high adoption rate of Bt-cotton in India without proper refugia has also brought bollworms under immense selection pressure which could lead to breakdown of resistance as exemplified by pink bollworm developing field resistance to cry1Ac and recently to cry2Ab in Gujarat state, geographically from central India. The resistance development in other cotton growing zones of India looms large on the horizon. The reduction in pink bollworm, as of now, might be due to its stenophagus/monophagous status. So, either the population of this pest will diminish with time or it will develop resistance to Bt-cotton. Under the prevailing situation, pink bollworm has greater chances of developing resistance to Bt-cotton.

The Bt-cotton era has witnessed upsurge in sucking insect-pest populations (Pandher et al 2011). The huge outbreak of whitefly in 2015 may be attributed to its early appearance i.e. first week of June and reaching ETL in mid-June. By mid of July, it rose above 100/3 leaves in almost all districts, the worst being in Fazilka where it reached up to 100-300 per 3 leaves. Whitefly remained at this level throughout July-August which led to sooty mold on leaves, yellowing and shedding of leaves, stunted growth of plants. This has contributed to nearly 50-60 damaged cotton crop across the Punjab State. The weather factors might have played a key role in this

outbreak. The maximum temperatures reached up to 43°C by the end of May - first week of June and remained near 40 throughout June. The minimum temperature also reached up to 29-30 C with light showers in every week of June which increased RH. Weather remained cloudy throughout July (24 cloudy days & 7 rainy days) with scattered showers at isolated places which hindered spraying by farmers or washed down the sprays (one of the reasons of failure of insecticidal sprays). Each standard week from 22nd till 34th (June-August) received light-moderate rains as compared to 2014 where 25, 26, 29-32nd standard week received rains. After 22nd Aug, there was a month of dry spell which might have led to decrease in whitefly numbers. Except 30th June and 7th July 2015 which received heavy rains, all other rainy days in June-July had light showers ranging from 2.6 – 21 mm. Total Rainfall and rainy days were more in 2015 as compared to 2014 but it was light and scattered widely thus not having much impact to physically dislodge whitefly population. Rather it led to development of hot and humid conditions favorable for whitefly increase. By the second week of September, the whitefly population reduced to 100/ 3 leaves which might be due to lower minimum RH /dry winds. After that, it continuously kept reducing reaching ETL by the end of September.

There are many more speculated factors after the introduction of Bt-cotton which might have played a role in the upsurge of sucking insect-pest population. There is a direct correlation of nitrogenous fertilizers with sucking insect-pest population in any crop. The high use of nitrogenous fertilizers in Bt-cotton which has increased about 2-3 times compared to the conventional cotton might have some role in this upsurge. The pace of introduction of Bt cotton hybrids in Punjab has increased from three in 2005 to 293 till April 2012. The huge introductions brings the state of confusion for both farmers (confused what to grow) and scientists (confused what to recommend) because it is high task for plant protection scientists to efficiently screen all the new introductions for insect-pest and diseases. The refugia, at present, has a very low compliance as the seed material supplied along with bt hybrids is mostly the segregating breeding material, poor quality and highly susceptible to insect-pest and diseases. So wherever planted, it may be contributing to the pest population build up. The seed treatment of cotton with imidaiclorprid is debatable. The historical pest data on Bt as well as non-Bt cotton suggests that the cotton leafhopper population appears in the third week of June in timely sown crop. So the need of seed treatment of imidaiclorprid which is also sprayed on crop might be playing a key role towards the resistance development in whiteflies and leafhoppers and also subsequently evolving highly resistant thrips' population which appear at seedling stage. All these issues along weather factors and many others may be considered to find the root cause of these huge insect-pest outbreaks.

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