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Influence of staggered sowing on pink bollworm, *Pectinophora gossypiella* (Saunders), incidence in Bt and non-Bt cotton in northern Karnataka

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Abstract

Bt cotton was mainly developed to control bollworms especially, American bollworm, *Helicoverpa armigera*, because it has developed high level of resistance to various insecticides mainly to synthetic pyrethroids. At the same time pink bollworm (PBW) was also under check due to introduction of Bt cotton since 2002. Recent days the pink bollworm become major threat to Bt cotton production and its incidence level is increasing year by year in the south India. Use of chemicals for the management of pink bollworm is ineffective since the larvae after emergence enter into the green bolls within one to two hours of hatching. So other tools will be more useful for the effective management of PBW in cotton. As a cultural method, staggered sowing has a great impact, hence present study was carried out with six dates of sowing. Results revealed that, incidence level of pink bollworm, *Pectinophora gossypiella* on both Bt and non-Bt cotton was less in normal sown cotton *i.e.*, June I fortnight (FN) and it was increased as sowing delays from June I FN to September I FN irrespective of Bt and non Bt cotton but the infestation level in Bt cotton was less when compare to non Bt cotton in all the normal and late sown cotton crops.

Keywords: Bt cotton, non Bt-cotton, pink bollworm, scars, insect damage

Introduction

Cotton is one of the economically and socially important cash crops in the world and a raw material for the textile industry. Cotton is an important fiber yielding crop hence called king of fibers or white gold. This is grown in tropical and subtropical regions of more than 80 countries of the world. Commercial cotton is grown in 77 countries and 123 countries are involved in the cotton related activities. India is the second largest producer of cotton. The area, production and productivity of cotton during 2016-17 was 105 lakh hectares, 351 lakh bales and 568 kg per hectare respectively (Anonymous, 2017) [1]. Karnataka is the fourth largest producer of cotton in India which is about 21 lakh bales and contributing about 7 percent of the country production within an area of 7.5 lakh hectares. Cotton is majorly grown in northern part of the Karnataka which offers ideal conditions for cotton production. The area production and productivity of cotton during 2017-18 in Karnataka accounts 5.65 lakh hectares, 19 lakh bales and 572 kg per hectare, respectively (Anonymous, 2017) [1]. India ranks first in the world with regard to cotton acreage, however the productivity is low as compared to other cotton growing countries. Among various factors responsible for this low yield, the losses caused by insect pests are of major importance. In India, over 160 species of insect pests have been reported to damage the crop, about dozens of pests causes economic damage as sap feeders and bollworms in different parts of the country. The sucking pests and bollworms on an average cause 52.1 percent loss of seed cotton yield (Dhawan *et al.*, 1988) [2]. Among the several pests, the bollworms commonly encountered in cotton cultivation are American bollworm, *Helicoverpa armigera* (Hubner); Spotted bollworm, *Earias vittella* (Fabricius); Tobacco cutworm, *Spodoptera litura* (Fabricius) and pink bollworm *Pectinophora gossypiella* (Saunders) (PBW). Among these, the pink bollworm is one of the most serious pests of cotton worldwide causing losses in both yield and quality of cotton (Parmar & Patel, 2016) [3]. During recent past, it has emerged as a major threat to cotton cultivation in southern and central parts of India and even on Bt cotton (Sarwar, 2017) [4]. Pink bollworm under unprotected condition known to cause 2.81 to 61.87 percent loss in seed cotton yield, 3.44 to 37.83 percent loss in germination, 2.12 to 47.13 percent loss in oil content and 10.66 to 59.15 percent loss in normal opening of bolls (Patil, 2003) [5].

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Recent days the pink bollworm incidence is increasing year by year because it has developed resistance against both Cry1Ac and Cry2Ab toxin (Kranthi, 2016) [6]. The purpose of the current experiment was to determine the impact of sowing dates on the occurrence of PBW while considering its significance for Bt cotton.

Material and Methods

The study was carried out at MARS farm, Raichur to know the effect of different dates of sowing on pink bollworm incidence in *Bt* comparison with non *Bt* cotton version of Ajeeth-155 with six sowing dates *viz.*, June I fortnight (FN), June II FN, and July I FN as normal sown crop and August I FN, August II FN, and September I FN as late sown crop. Observations on pink bollworm incidence on green boll damage and locule damage were recorded at 70, 90 and 110 DAS in all the dates of sowing in randomly selected ten plants. For this purpose, 25 green bolls were collected from that randomly selected ten plants and observed for the damage. From the same 25 bolls, observations on the presence of pink bollworm larvae and the number of scars inside the wall of bolls were recorded. Whereas observation on good opened bolls and bad opened bolls were recorded at the time of harvest. The crop was protected from early sucking pest complex by spraying selective systemic insecticides.

Statistical Analysis

The percent boll and locule damage were calculated by using the following formula.

$$\text{Percent incidence of bolls} = \frac{\text{Number of damaged green bolls}}{\text{Total numbers of bolls observed}} \times 100$$

$$\text{Percent locule damage} = \frac{\text{Number of locule damaged}}{\text{Total numbers of locules in damaged bolls}} \times 100$$

The data obtained on the incidence of pink bollworm were subjected to one way analysis of variance (ANOVA) using Web Agri. Stat Package (WASP) 2.0. The data was suitably transformed wherever necessary.

Results and Discussion

Incidence of pink bollworm in normal sown Bt and non-Bt cotton versions of Ajeeth-155 cotton hybrid

The incidence of pink bollworm on green bolls and locules along with scars on inside wall and larval number was observed on normal sown cotton crop *i.e.*, June I FN, June II FN and July I FN. On cotton crop which was sown during June I FN, the incidence of pink bollworm on green bolls and locule damage was low in both Bt cotton and non-Bt cotton with a mean green boll and locule damage of 12.00 and 7.41 percent and 20.00 and 32.22 percent, respectively when compared to June II FN and July I FN sown crop. The mean incidence of pink bollworm on green boll and locule damage in June II FN sown Bt cotton and non-Bt cotton crop was 18.67 and 29.17 and 21.67 and 40 percent, respectively and in July I FN sown Bt cotton and non-Bt cotton crop was 58.67 and 43.56 and 68.00 and 45.25 percent respectively. This clearly indicates that, the incidence of pink bollworm was increasing with delay in sowing dates. Among Bt cotton and non-Bt cotton the incidence level was high in non-Bt cotton than Bt cotton (Table 1).

The larval population of pink bollworm and scars on inside

the wall of cotton bolls also increased from June I FN sown to July I FN sown crop in both Bt cotton and non-Bt cotton. The mean number of larvae and scars in June I FN sown crop were 1.66 and 3.33 in Bt cotton and 1.33 and 4.33 in non-Bt cotton crop, respectively and in June II FN sown crop were 2 and 9.66 in Bt cotton and 1.66 and 5.33 in non-Bt cotton. This indicated that, there was no much difference in presence of larvae in Bt cotton and non-Bt cotton but with respect to scars on bolls significantly higher in June II FN sown than June I FN sown crop. Whereas in July I FN sown crop recorded 25 larvae and 21.66 scars in Bt cotton and 27.66 larvae and 38.66 scars in non-Bt cotton out of 25 bolls (Table 1). Observations on percent good opened bolls and bad opened bolls on Bt cotton and non-Bt cotton data revealed that, the percent GOB was high *i.e.*, 65.36 but BOB and LD were low (34.64 and 35.03%) on Bt cotton compared to non-Bt cotton where percent GOB was low (61.37%) but BOB and LD were high *i.e.*, 38.63 and 40.77 in June I FN sown cotton. Damage on open bolls due to PBW increased in June II FN (GOB, BOB and LD were 61.42, 38.24 and 54.81% in Bt cotton and 56.20, 43.8 and 58.34% in non-Bt cotton) and in July I FN sown crop (GOB, BOB and LD were 48.99, 51.01 and 66.17% in Bt cotton and 49.31, 50.69 and 71.37% in non-Bt cotton) compared to June I FN sown crop (Table 2).

Incidence of pink bollworm in late sown Bt cotton and non-Bt cotton versions of Ajeeth-155 cotton hybrid

The incidence of pink bollworm on green bolls and locules along with scars on inside wall and larval number was observed on late sown cotton crop *i.e.*, August I FN, August II FN and September I FN. The incidence of pink bollworm was high in late sown cotton crop compared to normal sown crop. The mean percent of damage on green bolls and locules was 62.67 and 45.42 percent in Bt cotton and 72.00 and 49.86 percent in non-Bt cotton, respectively in August I FN sown cotton which was less when compared to August II FN and September I FN in both Bt cotton and non-Bt cotton. In August II FN sown crop, the percent infestation on green bolls and locules damage was 76.00 and 60.95 percent in Bt cotton and 84.00 and 64.55 percent in non-Bt cotton, respectively. Whereas in September I FN sown cotton crop the incidence level was very severe compared to all other dates of sowing with a green boll and locule damage of 85.33 and 80.53 percent in Bt cotton and 93.33 and 82.16 percent in non-Bt cotton, respectively (Table 1).

The mean number of larvae and scars on inside wall of bolls increased from August I FN to September I FN sown crop. The peak larval populations and scars were recorded *i.e.*, 46.33 and 36.33 in Bt cotton and 57.66 and 57 in non-Bt cotton, respectively during September I FN sown crop compared to August I FN and August II FN. In August I FN and August II FN sown crop the mean number of larvae and scars were high but comparatively less as compare to September I FN sown crop. The mean larval population and scars in August I FN sown crop was 23.66 and 18.66 in Bt cotton and 31.66 and 27 in non-Bt cotton, respectively. Whereas in August II FN sown was 35.33 and 37 in Bt cotton and 43 and 46 in non-Bt cotton, respectively (Table 1). Observations on percent good opened bolls and bad opened bolls on Bt cotton and non-Bt cotton data revealed that, the percent GOB, BOB and LD was 44.28, 55.72 and 71.99 percent, respectively on Bt cotton compared to non-Bt cotton where percent GOB, BOB and LD was 37.72, 62.28 and 73.53, respectively in August I FN sown cotton. Damage on

open bolls was increased in August II FN (GOB, BOB and LD was 25.82, 74.18 and 78.94% in Bt cotton and 21.15, 78.85 and 84.42% in non-Bt cotton) and September I FN crop (GOB, BOB and LD were 4.09, 95.91 and 86.37% in Bt cotton and 1.66, 98.44 and 93.31% in non-Bt cotton, respectively) compared to August I FN sown crop (Table 2). The availability of literature on the influence of different dates of sowing on pink bollworm incidence is very scanty and the present work is discussed here under with available references. The incidence of pink bollworm on green bolls revealed that the mean damage by pink bollworm, *P. gossypiella* in Bt cotton on green bolls and locules was very less in normal sown cotton crop especially in June I FN with a damage of 12.00 and 7.41 percent on green bolls and locules, respectively whereas in non Bt cotton 20.00 and 32.22 percent, respectively compared to other dates of sowing. Among Bt cotton and non-Bt cotton, more incidence was observed in non Bt cotton in all the normal sown dates than Bt cotton. These observations are in close agreement with Patil (2003) who observed 32.28 percent incidence in June 10th sown non-Bt cotton (DCH-32) [5]. The results of pink bollworm incidence on green bolls in August I FN sown cotton in the current study revealed that the mean green boll and locule damage by pink bollworm, *P. gossypiella* in Bt cotton was 62.67 and 45.42 percent, respectively. In non-Bt cotton, the damage was significantly higher in comparison with Bt cotton with a green boll and locules of 72 and 49.86 percent respectively. These observations are in close

agreement with Sangareddy and Patil (1997) who reported that the highest damage of 78.4 percent in 1st August sown non Bt cotton (DCH-32) [7]. Sarma and Senguttuvan (2011) [8] revealed that there was no damage by pink bollworm in Bt cotton as compared to non-Bt cotton, which recorded 1-3 percent flower damage, 4-12 percent green boll damage and 1-3 percent locule damage in August 13th sown crop [8]. These findings are contradictory with the present investigations. Since they recorded no damage on Bt cotton due to insect might have not shown any resistance to *Cry* toxin during the period of study. In August II FN sown cotton, the mean green boll and locule damage by pink bollworm, *P. gossypiella* in Bt cotton were 76 and 60.95 percent, respectively. These results are in close agreement with Sapna (2014) who recorded the green boll damage of 70.66 percent in August 15th sown non-Bt cotton crop [10]. The damage on green bolls and locules were significantly higher in comparison with Bt cotton with a green boll and locule damage of 84 and 64.55 percent, respectively. The higher percent of locule damage was due to the multiplication of initial infestation of pink bollworm and peak reproductive growth might have coincided with peak activity of the pink bollworm. The incidence of pink bollworm on green bolls in September I FN sown cotton revealed that the mean green boll and locule damage in Bt cotton were 85.33 and 80.53 percent, respectively. In non-Bt cotton, the damage on green bolls and locules were 93.33 and 77.83 percent, respectively.

Table 1: Incidence of pink bollworm in Bt and non-Bt cotton

Sowing time	Sowing date	Green boll damage (%)		Locule damage (%)		Number of PBW larvae		Number of Scars	
		Bt	Non-Bt	Bt	Non-Bt	Bt	Non-Bt	Bt	Non-Bt
Normal sowing	June I FN	12.00±5.29 ^c (19.99)	20.00±16.0 ^c (24.99)	7.41±2.51 ^d (15.64)	32.22±18.44 ^c (33.98)	1.67±1.15 ^c (1.44)	1.33±0.58 ^c (1.34)	3.33±1.53 ^c (1.79)	4.33±2.08 ^d (2.15)
	June II FN	18.67±10.26 ^c (25.07)	21.67±3.51 ^c (27.69)	29.17±3.82 ^c (32.65)	40.00±10.00 ^c (39.14)	2.00±1.00 ^c (1.55)	1.67±1.15 ^c (1.44)	9.67±8.96 ^{bc} (2.90)	5.33±2.52 ^d (2.37)
	July I FN	58.67±34.49 ^b (52.18)	68.00±30.2 ^b (57.79)	43.56±24.51 ^{bc} (40.84)	45.25±26.23 ^c (41.98)	25.00±11.27 ^b (4.83)	27.67±18.50 ^b (5.08)	15.00±8.54 ^b (3.76)	25.33±14.57 ^c (4.92)
Late sowing	August I FN	62.67±32.08 ^b (54.56)	72.00±28.84 ^b (60.37)	45.42±26.06 ^{bc} (42.02)	49.86±26.12 ^{bc} (44.98)	23.67±10.60 ^b (4.95)	31.67±5.69 ^d (5.65)	18.67±12.90 ^b (4.14)	27.00±15.72 ^{bc} (5.06)
	August II FN	76.00±28.84 ^{ab} (65.80)	84.00±24.33 ^{ab} (72.11)	60.95±15.71 ^b (51.50)	64.55±23.47 ^b (54.35)	35.33±12.86 ^{ab} (5.92)	43.00±8.19 ^{ab} (6.57)	37.00±22.61 ^a (5.83)	46.00±24.27 ^{ab} (6.62)
	September I FN	85.33±18.90 ^a (72.04)	93.33±11.55 ^a (80.76)	80.53±18.34 ^a (65.24)	82.17±17.90 ^a (66.62)	46.33±26.76 ^a (6.66)	57.67±20.55 ^a (7.54)	36.33±20.84 ^a (5.86)	57.00±22.61 ^a (7.47)
C.V	19.014	16.545	17.040	13.005	18.715	19.120	18.87	18.655	C.V
C.D @0.05	16.699	16.239	12.808	11.083	1.440	1.62	1.39	1.61	C.D @0.05

Table 2: Observation on good opened bolls and bad opened bolls at the time of harvest

Different Dates of Sowing	Bt cotton			Non-Bt cotton		
	%GOB	%BOB	%LD	%GOB	%BOB	%LD
June I FN	65.36±5.11 ^a (53.98)	34.64±5.65 ^d (36.01)	35.03±4.58 ^e (36.26)	61.37±4.07 ^a (51.58)	38.63±2.83 ^e (38.42)	40.77±3.61 ^e (39.67)
June II FN	61.42±3.26 ^a (51.61)	38.24±4.04 ^d (38.18)	54.81±4.41 ^d (47.76)	56.20±3.24 ^a (48.56)	43.80±1.85 ^e (41.43)	58.34±2.58 ^d (49.80)
July I FN	48.99±10.54 ^b (44.40)	51.01±4.00 ^c (45.58)	66.17±2.95 ^c (54.44)	49.31±3.98 ^b (44.60)	50.69±2.60 ^d (45.39)	71.37±2.48 ^c (57.66)
August I FN	44.28±8.37 ^b (41.67)	55.72±4.67 ^c (48.29)	71.99±4.00 ^{bc} (58.08)	37.72±2.63 ^c (37.88)	62.28±1.77 ^c (52.11)	73.53±3.08 ^c (59.06)
August II FN	25.82±6.26 ^c (30.42)	74.18±4.93 ^b (59.52)	78.94±6.00 ^{ab} (62.83)	21.15±2.12 ^d (27.36)	78.85±2.86 ^b (62.65)	84.42±1.83 ^b (66.77)
September I FN	04.09±2.05 ^d (11.41)	95.91±2.31 ^a (78.61)	86.37±4.26 ^a (68.49)	01.66±0.8 ^e (07.24)	98.44±1.63 ^a (83.57)	93.31±2.97 ^a (75.26)
C.V	3.989	5.987	5.834	5.678	3.945	2.039
C.D @0.05	2.824	5.559	5.800	3.740	3.870	2.153

Conclusion

The current study showed that the incidence trend of pink bollworm in both Bt cotton and non-Bt cotton was low in early sown cotton, *i.e.*, June I FN, and highly severe in August II FN and September I FN sown cotton. When comparing Bt cotton and non-Bt cotton, non-Bt cotton had a higher level of infection. This reveals that regardless of *Bt* or non-Bt cotton, the incidence of pink bollworm increases as sowing is delayed from June to September. These findings with regard to various sowing dates disclosed that pink bollworm infestation was least in early planted crops, and incidence steadily increases with sowing delay. Early sowing and avoiding late sowing are both recommended for managing the pink bollworm incidence.

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