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Incidence of Pink Bollworm *Pectinophora gossypiella* on different *Bt* cotton Hybrids under different Sowing Regimes

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ABSTRACT: The incidence of pink bollworm (*Pectinophora gossypiella*) is of significant importance in the context of agriculture, particularly in cotton-growing regions around the world. Pink bollworm is a destructive pest that primarily affects cotton crops, and its presence can have far-reaching consequences for both farmers and the cotton industry. Different sowing regimes, which include variations in the timing can have a significant impact on cotton yield and the prevalence of pests. Likewise, present investigation was conducted at the Centre for agro-climatic Studies, MARS, UAS Raichur, during *Kharif*-2019. Eight different *Bt* cotton hybrids were selected from the locally available market. They were used to estimate pink bollworm damage with two other dates of sowings in factorial randomized block design. The results revealed that among the different *Bt* cotton hybrids, the Bindaas-7213 hybrid recorded the lowest rosette flowers, green boll damage and locule damage (6.62, 21.62 and 18.72 %, respectively) were recorded in both regular and late sowing regimes. The lowest pink bollworm infestation at harvest was observed in normal sowing (39.80 GOBs/plant), with the highest seed cotton yield (16.99 q/ha) recorded in the Bindaas-7213 *Bt* hybrid. In contrast, the minimum seed cotton yield (10.23 q/ha) was recorded in the PCH-5678 *Bt* hybrid. The maximum pink bollworm infestation was noticed in the late sowing regime compared to the regular sowing regime.

Keywords: Agro-climate, factorial, hybrids pink bollworm and regime.

INTRODUCTION

Cotton, *Gossypium* spp., is one of the principal commercial fibre crops, which plays a prominent role in the national and international economy and is grown in tropical and subtropical regions of more than 111 countries. India is an essential cotton grower among all the cotton-producing countries globally and ranks first in area (129.57 lakh ha) with a production of 371 lakh bales and productivity of 487 kg lint ha^{-1}. Maharashtra, Gujarat, and Telangana are the major cotton-growing states according to 69.60 per cent (87.59 lakh ha) area under cotton cultivation and 63.88 per cent (230 lakh bales) of cotton production in India. In Karnataka, it is cultivated over 5.50 lakh ha with a production of 18.00 lakh bales and productivity of 556 kg ha-1 (Anon., 2021).

The pink bollworm *Pectinophora gossypiella* (Saunders) is the most important cotton pest in the world (Amin and Gergis 2006) and reported greatest loss (20-40%) in cotton seed yield. It is distributed in almost all cotton growing states and has caused millions of rupees of damage. An oligophagous pest feeds on cotton, okra, and allied plants. It has been a significant pest of cotton produced in the southwestern United States for many years. The pink bollworm is back with a vengeance. This insect was a serious concern for cotton in India about 30 years ago. There have been very few reports of any major damage by pink bollworms to cotton since 1982 in the country. But all that has changed now. Pink bollworm is the most destructive pest of cotton in the later stages of crop growth. It causes locule damage of 37.5 per cent and 13.58 per cent on non-*Bt* and *Bt* cotton, respectively, at 160 days of planting, resulting in heavy loss in cotton production (Naik *et al.*, 2014). During 2014, severe damage to bolls by pink bollworms and yield losses were observed in *Bt* cotton in many regions of Gujarat and some parts of AP, Telangana and Maharashtra. More concerning is that the worm is happily chewing up Bollgard-II-Bt-cotton, which contains two genes (cry1Ac+cry2Ab) that were supposed to be highly effective in controlling the pest (Kranthi, 2015).

MATERIALS AND METHODOLOGY

The experiment was conducted at the Centre for Agro-climatic Studies, Main Agriculture Research Station (MARS), University of Agricultural Science, Raichur during *Kharif* 2019-20. Popular *Bt* cotton hybrids grown

by farmers of Raichur districts were selected (in consultation with principal scientists and cotton breeder of UAS, Raichur) and grown on two different planting dates, *i.e*., early planting (20th July 2019) and late planting (15th August 2019). Intentionally, these two plantings were done as Raichur district happens to be a tail-end region of the Tungabhadra command project wherein the farmers get irrigation water (canal) in the 1st or 2nd fortnight of August (depending upon receipt of rainfall).

A. Raising of popular Bt cotton hybrids in the field

The experiment was laid out in a factorial randomized complete block design with three replications in a plot size of 4.50 × 3.60 m^2 (each treatment plot consists of 36 plants). Wherein eight popular *Bt* cotton hybrids (Event MON15985) were procured from the local market and were sown on 20th July 2019 (as Normal sowing) and 15th August 2019 (as late sowing) in deep black cotton soil with inter-row spacing of 90 cm and intra row spacing of 60 cm. All agronomic practices followed were as per the package of practice prescribed by UAS, Raichur, (Anon., 2020) except for plant protection measures against bollworm complex. While sucking, pests were kept under check by spraying of systemic insecticides. Harvesting of seed cotton was done thrice by following its harvest index.

Periodic observations were undertaken to record the incidence of bollworms *viz*., per cent green boll damage, per cent rosette flowers, locule damage, number of larvae per plant and natural enemies (Coccinellids, Spiders and Chrysopids) were recorded on five randomly tagged plants in each replication at 60, 70, 80, 90, 100, 110 and 120 days after sowing.

Procedures followed in calculating the above observations were detected as under

B. Flower damage

The incidence of pink bollworm larvae on flowers was recorded as rosette flowers. The per cent rosette flower was calculated by using the given formulae.

$$\text{Rosette flowers (\%)} = \frac{\text{Number of rosette flowers}}{\text{Total number of flowers}} \times 100$$

C. Green bolls damage

Twenty green bolls were plucked randomly from the five tagged plants from each treatment and brought to the laboratory and cut opened to see the number of bolls damaged and locule damage to know the incidence of pink bollworm. The green boll damage was calculated using the formulae given below.

$$\text{Green boll damage (\%)} = \frac{\text{Number of green bolls with PBW larvae}}{\text{Total number of green bolls}} \times 100$$

D. Locule damage

At each picking, 50 bolls per replication were selected randomly and observed for locule damage, and later, per cent locule damage was calculated under

$$\text{Locule damage (\%)} = \frac{\text{Number of locule damage}}{\text{Total number of locule observed}} \times 100$$

E. Data analysis

The data generated on several larvae were subjected to square root ($\sqrt{X} + 0.5$) transformations. The per cent values such as rosette flowers, green boll damage and locules damage were transformed to arc sine values. Later, all the transformed values were subjected to one-way ANOVA using MSTATC® software and treatment performances were compared through DMRT.

RESULTS AND DISCUSSION

A. Rosette flower damage due to pink bollworm in different Bt cotton hybrids

The data presented in Table 1 indicated that the maximum pink bollworm menace in rosette flower damage was recorded in the late sowing regime (13.63 %), and the minimum was recorded in the normal sowing regime (11.97 %) at 110 DAS. The pink bollworm incidence was observed in the range of 2.90 to 11.97 per cent in normal sowing and 4.07 to 13.67 per cent in late sowing regimes. However, the infestation of pink bollworm (per cent rosette flower damage) during the season indicated the significant variation between the normal sowing and late sowing. The cumulative data on infestation of pink bollworm in late sowing (9.48 %) was significantly higher than normal sowing (7.78 %). The cumulative data among the different *Bt* cotton hybrids shows that a minimum of 6.62 per cent of rosette flowers was recorded in Bindaas-7213 *Bt* cotton hybrid. At the same time, a maximum of 11.08 per cent rosette flower damage was recorded in the ACH-1155 *Bt* cotton hybrid, which was on par with the PCH-5678 hybrid. In both dates of sowing regimes Bindas-7213 *Bt* cotton hybrid which recorded lowest damage.

B. Green boll damage due to pink bollworm in different Bt cotton hybrids

The data presented in Table 2 indicated that the maximum pink bollworm infestation of green boll damage (63.56 %) was found in the late sowing regime compared to the normal sowing (60.77 %) at 120 DAS. The cumulative data showed that different *Bt* cotton hybrids' maximum per cent r boll damage (28.79 %) due to pink bollworm was recorded in the ACH-1155 *Bt* hybrid. At the same time, minimum green boll damage was observed in Bindaas-7213 (21.62 %), which was on par with Yuva-7215 (22.28 %). The lowest green boll damage due to pink bollworm infestation was recorded in normal sowing regime, then the late sowing. The interaction between dates of sowing and different *Bt* cotton hybrids, the Bindaas-7213 hybrid recorded the least green boll damage in both normal and late sowing regimes.

C. Locule damage due to pink bollworm in different Bt cotton hybrids

The data presented in Table 2 indicated that the maximum pink bollworm infestation of green boll damage (63.56 %) was found in the late sowing regime compared to the normal sowing (60.77 %) at 120 DAS. The cumulative data showed that different *Bt* cotton hybrids' maximum per cent r boll damage (28.79 %) due to pink bollworm was recorded in the ACH-1155 *Bt* hybrid. At the same time, minimum green boll damage was observed in Bindaas-7213 (21.62 %), which was on par with Yuva-7215 (22.28 %). The lowest green boll damage due to pink bollworm infestation was recorded in the normal sowing regime, then the late sowing. The interaction between dates of sowing and different *Bt* cotton hybrids, the Bindaas-7213 hybrid

recorded the least green boll damage in both normal and late sowing regimes.

These results stand in the persuasion of Nadaf and Basavagoud (2006); Muttappa and Patil (2019), who reported that the incidence was noticed from the first fortnight of September and increased gradually with the progression of crop growth, reaching its peak incidence during the second fortnight of September. Likewise, Verma *et al*. (2017) reported that the pink bollworm infestation on flowers was found to be highest in 2nd week of September (7 larvae/ 30 flowers). Naik *et al*. (2014) reported that the incidence and damage caused by pink bollworm on different *Bt* cotton hybrids grown under rainfed and irrigated conditions at Nagpur and Coimbatore were maximum locule damage on PA255 at 145 DAS and AKH- 8828 *Bt* cotton hybrids were observed under rainfed conditions.

Table 1: Influence dates of sowing of different *Bt* cotton hybrids on the pink bollworm incidence.

Per cent rosette flowers at different intervals								
Treatment details	**60 DAS**	**70 DAS**	**80 DAS**	**90 DAS**	**100 DAS**	**110 DAS**	**120 DAS**	**Cumulative Mean**
I Factor A - Sowing dates								
D_1 : Early sowing (20^{th} July, 2019)	1.08 (5.97)^{a}	2.90 (9.80)^{a}	6.84 (15.16)^{a}	9.75 (18.19)^{a}	11.09 (19.45)^{a}	11.97 (20.24)^{a}	10.84 (19.22)^{a}	7.78 (16.20)^{a}
D_2 : Late sowing (15^{th} August, 2019)	1.96 (8.05)^{b}	4.07 (11.64)^{b}	8.93 (17.39)^{b}	12.43 (20.64)^{b}	13.25 (21.35)^{b}	13.63 (21.67)^{b}	12.06 (20.32)^{b}	9.48 (17.93)^{b}
S. Em (±)	**0.09**	**0.10**	**0.16**	**0.24**	**0.26**	**0.28**	**0.23**	**0.19**
C.D (P=0.05)	**0.28**	**0.30**	**0.48**	**0.72**	**0.78**	**0.84**	**0.69**	**0.57**
C.V (%)	**11.42**	**11.06**	**9.98**	**10.69**	**10.48**	**10.61**	**9.73**	**10.57**
II Factor B - Different *Bt* Cotton Hybrids								
H_1 : KCH -14K59	1.31 (6.57)^{b}	2.98 (9.94)^{b}	7.04 (15.39)^{bc}	9.42 (17.87)^{b}	10.44 (18.85)^{bc}	11.04 (19.41)^{b}	10.05 (18.48)^{b}	7.47 (15.86)^{bc}
H_2 : RCH 530	1.64 (7.36)^{c}	3.47 (10.74)^{d}	8.44 (16.89)^{cde}	10.92 (19.30)^{c}	11.85 (20.14)^{d}	12.94 (21.08)^{d}	11.07 (19.43)^{c}	8.62 (17.07)^{d}
H_3 : RCH 578	1.73 (7.56)^{c}	3.92 (11.42)^{e}	8.96 (17.42)^{d}	12.75 (20.92)^{d}	13.37 (21.45)^{e}	14.03 (22.00)^{e}	12.65 (20.83)^{d}	9.63 (18.08)^{e}
H_4 : ACH-1155	2.01 (8.15)^{d}	4.55 (12.32)^{f}	9.67 (18.12)^{e}	14.61 (22.47)^{f}	15.61 (23.27)^{f}	16.20 (23.73)^{f}	14.94 (22.60)^{e}	11.08 (19.45)^{f}
H_5 : ACH 155	1.36 (6.70)^{b}	3.22 (10.34)^{c}	7.53 (15.93)^{bcd}	9.83 (18.27)^{b}	11.02 (19.39)^{c}	11.74 (20.04)^{c}	10.38 (18.79)^{b}	7.87 (16.29)^{c}
H_6 : PCH-5678	1.94 (8.01)^{d}	4.42 (12.14)^{f}	9.31 (17.77)^{e}	13.81 (21.82)^{e}	14.97 (22.76)^{f}	15.73 (23.73)^{f}	14.16 (22.10)^{e}	10.62 (19.02)^{f}
H_7 : Bindaas-7213	0.98 (5.68)^{a}	2.57 (9.23)^{a}	5.44 (13.49)^{a}	8.49 (16.94)^{a}	9.73 (18.18)^{a}	10.21 (18.63)^{a}	8.94 (17.40)^{a}	6.62 (14.91)^{a}
H_8 : Yuva- 7215	1.19 (6.26)^{ab}	2.72 (9.49)^{a}	6.71 (15.01)^{ab}	8.90 (17.36)^{a}	10.35 (18.77)^{ab}	10.51 (18.92)^{a}	9.41 (17.86)^{a}	7.11 (15.47)^{ab}
S. Em (±)	**0.20**	**0.09**	**0.50**	**0.15**	**0.20**	**0.12**	**0.17**	**0.19**
C.D (P=0.05)	**0.62**	**0.27**	**1.53**	**0.48**	**0.61**	**0.38**	**0.53**	**0.59**
C.V (%)	**11.42**	**11.06**	**9.98**	**10.69**	**10.48**	**10.61**	**9.73**	**10.57**
III Interaction (A × B)								
D_1H_1	1.08 (5.97)	2.43 (8.97)	5.65 (13.75)	8.55 (17.00)	9.58 (18.03)	10.30 (18.72)	9.87 (18.31)	6.78 (15.09)
D_1H_2	1.13 (6.10)	2.85 (9.72)	7.47 (15.86)	9.69 (18.14)	11.26 (19.61)	12.54 (20.74)	10.36 (18.78)	7.90 (16.32)
D_1H_3	1.18 (6.24)	3.11 (10.16)	8.19 (16.63)	10.76 (19.15)	11.98 (20.25)	12.90 (21.05)	11.62 (19.93)	8.53 (16.99)
D_1H_4	1.26 (6.45)	3.96 (11.48)	9.01 (17.47)	12.76 (20.93)	13.79 (21.80)	14.85 (22.67)	13.89 (21.88)	9.93 (18.37)
D_1H_5	1.11 (6.05)	2.59 (9.26)	5.96 (14.13)	8.94 (17.40)	10.14 (18.57)	11.04 (19.41)	10.05 (18.48)	7.12 (15.47)
D_1H_6	1.22 (6.34)	3.79 (11.23)	8.60 (17.05)	12.18 (20.43)	13.37 (21.45)	14.63 (22.49)	13.20 (21.30)	9.57 (18.02)
D_1H_7	0.67 (4.70)	2.17 (8.47)	4.48 (12.22)	7.64 (16.05)	8.97 (17.43)	9.65 (18.110)	8.65 (17.10)	6.03 (14.22)
D_1H_8	1.00 (5.74)	2.31 (8.74)	5.38 (13.41)	8.03 (16.46)	9.33 (17.79)	9.89 (18.33)	9.06 (17.52)	6.43 (14.69)
D_2H_1	1.53 (7.11)	3.54 (10.84)	8.43 (16.88)	10.28 (18.70)	11.03 (19.40)	11.79 (20.08)	10.22 (18.64)	8.12 (16.55)
D_2H_2	2.16 (8.45)	4.09 (11.67)	9.40 (17.85)	12.15 (20.40)	12.43 (20.64)	13.34 (21.42)	11.79 (20.08)	9.34 (17.79)
D_2H_3	2.28 (8.68)	4.73 (12.56)	9.72 (18.17)	15.28 (23.01)	14.75 (22.59)	15.16 (22.91)	13.68 (21.71)	10.80 (19.19)
D_2H_4	2.75 (9.55)	5.14 (13.10)	10.33 (18.75)	16.47 (23.94)	17.42 (24.67)	17.56 (24.77)	15.98 (23.56)	12.24 (20.47)
D_2H_5	1.61 (7.29)	3.86 (11.33)	9.10 (17.56)	10.72 (19.11)	11.90 (20.18)	12.45 (20.66)	10.71 (19.10)	8.62 (17.07)
D_2H_6	2.66 (9.39)	5.06 (13.00)	10.01 (18.44)	15.44 (23.14)	16.58 (24.03)	16.83 (24.22)	15.12 (22.88)	11.67 (19.98)
D_2H_7	1.29 (6.52)	2.97 (9.92)	6.40 (14.65)	9.34 (17.80)	10.48 (18.89)	10.77 (19.16)	9.23 (17.69)	7.21 (15.58)
D_2H_8	1.37 (6.72)	3.13 (10.19)	8.04 (16.47)	9.78 (18.22)	11.37 (19.71)	11.14 (19.50)	9.75 (18.19)	7.80 (16.21)
F. test	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S. Em (±)	**0.25**	**0.24**	**0.45**	**0.68**	**0.74**	**0.78**	**0.64**	**0.53**
C.D (P=0.05)	**0.72**	**0.72**	**1.35**	**2.04**	**2.22**	**2.34**	**1.92**	**1.59**
C.V (%)	**11.42**	**11.06**	**9.98**	**10.69**	**10.48**	**10.61**	**9.73**	**10.57**

** Significant @ 5 % DAS: Days after sowing H: Different *Bt* cotton hybrids

Means denoted by same letters in vertical column are not significantly different by DMRT

Table 2: Influence dates of sowing of different *Bt* cotton hybrids on the pink bollworm incidence.

Per cent green boll damage at different intervals								
Treatment details	**60 DAS**	**70 DAS**	**80 DAS**	**90 DAS**	**100 DAS**	**110 DAS**	**120 DAS**	**Cumulative Mean**
I Factor A - Sowing dates								
D_1 : Early sowing (20th July, 2019)	1.29 (6.52)[a]	2.26 (8.65)[a]	6.45 (14.71)[a]	13.52 (21.57)[a]	32.52 (34.77)[a]	49.82 (44.90)[a]	60.77 (51.22)[a]	23.80 (29.20)[a]
D_2 : Late sowing (15th August, 2019)	1.65 (7.38)[b]	3.59 (10.92)[b]	8.34 (16.79)[b]	15.18 (22.93)[b]	35.29 (36.45)[b]	53.15 (46.81)[b]	63.56 (52.87)[b]	25.82 (30.54)[b]
S. Em (±)	**0.05**	**0.08**	**0.17**	**0.31**	**0.50**	**0.51**	**0.43**	**0.40**
C.D (P=0.05)	**0.15**	**0.24**	**0.51**	**0.93**	**1.52**	**1.54**	**1.29**	**1.22**
C.V (%)	**10.75**	**10.41**	**11.26**	**10.59**	**10.75**	**9.83**	**10.17**	**10.54**
II Factor B - Different *Bt* cotton hybrids								
H_1 : KCH -14K59	1.19 (6.26)[bc]	2.36 (8.84)[bc]	6.18 (14.39)[bc]	13.55 (21.60)[bc]	31.60 (34.20)[b]	49.01 (44.43)[b]	58.57 (49.93)[bc]	23.21 (28.80)[b]
H_2 : RCH 530	1.33 (6.62)[cd]	2.77 (9.58)[d]	7.46 (15.85)[d]	14.32 (22.24)[de]	33.83 (35.57)[c]	52.38 (46.36)[c]	62.04 (51.97)[d]	24.88 (29.92)[d]
H_3 : RCH 578	1.50 (7.03)[d]	3.18 (10.27)[e]	8.09 (16.52)[e]	14.65 (22.50)[e]	34.70 (36.09)[c]	54.39 (47.52)[d]	64.24 (53.27)[e]	25.82 (30.54)[e]
H_4 : ACH-1155	2.31 (8.74)[e]	4.25 (11.90)[g]	10.19 (18.62)[f]	16.63 (24.07)[f]	40.03 (39.25)[d]	58.25 (49.75)[e]	69.85 (56.70)[f]	28.79 (32.45)[f]
H_5 : ACH 155	1.27 (6.47)[bcd]	2.45 (9.01)[c]	6.49 (14.76)[c]	13.89 (21.88)[cd]	32.16 (34.55)[b]	49.69 (44.82)[b]	59.57 (50.52)[c]	23.65 (29.10)[c]
H_6 : PCH-5678	2.13 (8.39)[e]	4.02 (11.57)[f]	9.78 (18.22)[f]	16.33 (23.83)[f]	38.96 (38.62)[d]	57.80 (49.49)[e]	68.85 (56.07)f	28.27 (32.12)[f]
H_7 : Bindaas-7213	0.94 (5.56)[a]	2.17 (8.47)[a]	5.25 (13.25)[a]	12.42 (20.64)[a]	29.47 (32.88)[a]	44.64 (41.92)[a]	56.46 (48.71)[a]	21.62 (27.71)[a]
H_8 : Yuva- 7215	1.12 (6.07)[ab]	2.25 (8.63)[ab]	5.71 (13.82)[ab]	13.03 (21.16)[ab]	30.49 (33.52)[a]	45.69 (42.53)[a]	57.70 (49.43)[ab]	22.28 (28.17)[a]
S. Em (±)	**0.18**	**0.09**	**0.20**	**0.18**	**0.22**	**0.25**	**0.24**	**0.16**
C.D (P=0.05)	**0.56**	**0.27**	**0.62**	**0.53**	**0.66**	**0.77**	**0.74**	**0.49**
C.V (%)	**10.75**	**10.41**	**11.26**	**10.59**	**10.75**	**9.83**	**10.17**	**10.54**
III Interaction (A × B)								
D_1H_1	1.06 (5.91)	1.64 (7.36)	5.31 (13.32)	12.86 (21.01)	30.32 (33.41)	47.95 (43.83)	57.77 (49.47)	22.42 (28.26)
D_1H_2	1.15 (6.16)	2.18 (8.49)	6.49 (14.76)	13.66 (21.69)	32.45 (34.73)	51.61 (45.92)	60.83 (51.25)	24.05 (29.37)
D_1H_3	1.22 (6.34)	2.46 (9.02)	7.04 (15.39)	13.93 (21.91)	33.22 (35.20)	52.80 (46.61)	62.61 (52.30)	24.75 (29.84)
D_1H_4	2.09 (8.31)	3.58 (10.91)	9.41 (17.86)	15.71 (23.35)	39.17 (38.75)	56.38 (48.67)	67.54 (55.27)	27.70 (31.75)
D_1H_5	1.11 (6.05)	1.95 (8.03)	5.63 (13.73)	13.06 (21.19)	30.88 (33.76)	48.42 (44.09)	58.83 (50.09)	22.84 (28.55)
D_1H_6	1.95 (8.03)	3.32 (10.50)	9.07 (17.53)	15.51 (23.19)	38.08 (38.10)	55.92 (48.40)	66.02 (54.34)	27.12 (31.39)
D_1H_7	0.75 (4.97)	1.45 (6.92)	4.06 (11.62)	11.29 (19.63)	27.66 (31.73)	42.33 (40.59)	55.74 (48.30)	20.47 (26.90)
D_1H_8	1.02 (5.80)	1.53 (7.11)	4.60 (12.38)	12.18 (20.43)	28.38 (32.19)	43.11 (41.04)	56.62 (48.80)	21.06 (27.32)
D_2H_1	1.31 (6.57)	3.07 (10.09)	7.05 (15.40)	14.23 (22.16)	32.88 (34.99)	50.06 (45.03)	59.38 (50.41)	24.00 (29.33)
D_2H_2	1.50 (7.03)	3.35 (10.55)	8.44 (16.89)	14.98 (22.77)	35.22 (36.40)	53.15 (46.81)	63.21 (52.66)	25.69 (30.46)
D_2H_3	1.78 (7.67)	3.89 (11.38)	9.13 (17.59)	15.37 (23.08)	36.18 (36.98)	55.98 (48.43)	65.87 (54.25)	26.89 (31.23)
D_2H_4	2.52 (9.13)	4.93 (12.83)	10.97 (19.34)	17.54 (24.76)	40.88 (39.75)	60.12 (50.84)	72.15 (58.15)	29.87 (33.13)
D_2H_5	1.43 (6.87)	2.94 (9.87)	7.36 (15.74)	14.72 (22.56)	33.43 (35.32)	50.96 (45.55)	60.32 (50.96)	24.45 (29.64)
D_2H_6	2.30 (8.72)	4.72 (12.55)	10.49 (18.90)	17.15 (24.46)	39.84 (39.14)	59.68 (50.58)	71.69 (57.85)	29.41 (32.84)
D_2H_7	1.12 (6.07)	2.88 (9.77)	6.45 (14.71)	13.55 (21.60)	31.27 (34.00)	46.94 (43.25)	57.18 (49.13)	22.77 (28.50)
D_2H_8	1.21 (6.32)	2.97 (9.92)	6.82 (15.14)	13.89 (21.88)	32.60 (34.82)	48.27 (44.01)	58.66 (49.99)	23.49 (28.99)
F. test	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S. Em (±)	**0.15**	**0.24**	**0.48**	**0.88**	**2.10**	**2.92**	**3.53**	**1.47**
C.D (P=0.05)	**0.45**	**0.72**	**1.44**	**2.64**	**6.30**	**8.76**	**10.59**	**4.41**
C.V (%)	**10.75**	**10.41**	**11.26**	**10.59**	**10.75**	**9.83**	**10.17**	**10.54**

** Significant @ 5 % DAS: Days after sowing H: Different *Bt* cotton hybrids
Figures in the parentheses indicate Arc sine transformation
Means denoted by same letters in vertical column are not significantly different by DMRT

D. Yield of seed cotton (Quintal per hectare)

The data recorded at the time of harvesting indicated that the yield of seed cotton under different sowing dates was significantly higher (15.49 q/ha) in normal sowing than in late sowing (11.82 q/ha). The highest yield (16.99 q /ha) was recorded in the Bindaas-7213 *Bt* hybrid, followed by the Yuva-7215 *Bt* hybrid (16.19 q/ha), and the lowest yield (10.23 q/ha) was recorded in the PCH-5678 *Bt* hybrid (Table 4).

The interaction between dates of sowing and different *Bt* cotton hybrids Bindaas-7213 *Bt* cotton hybrid was found to be significantly superior concerning the lower incidence and higher seed cotton yield in both sowing dates. The results of the present study are similar to the findings of Ingole *et al*. (2019), who reported that the yield of seed cotton under different sowing dates was significantly higher in early sowing than in late sowing. The present findings corroborate with Pooja (2019); Shrilakshmi (2021), who reported that the different sowing regimes have a more significant influence on yield, wherein yield levels were usually higher in early sown compared to late planted crops.

Table 3: Per cent locule damage due to pink bollworm incidence in different *Bt* cotton hybrids as influenced by dates of sowing.

Per cent locule damage in different intervals				
Treatment	**90 DAS**	**120 DAS**	**135 DAS**	**Cumulative mean**
I Factor A - Sowing dates				
D_1 : Early sowing (20th July, 2019)	13.66 (21.69)[a]	25.53 (30.35)[a]	33.16 (35.16)[a]	24.12 (29.07)[a]
D_2 : Late sowing (15th August, 2019)	18.24 (25.28)[b]	29.54 (32.92)[b]	40.12 (39.30)[b]	29.30 (32.50)[b]
S. Em (±)	**0.48**	**0.72**	**0.47**	**0.56**
C.D (P=0.05)	**1.39**	**2.06**	**1.35**	**1.60**
C.V (%)	**14.81**	**12.75**	**12.93**	**13.50**
II Factor B - Different *Bt* cotton hybrids				
H_1 : KCH -14K59	14.58 (22.45)[b]	24.07 (29.38)[b]	34.73 (36.11)[b]	24.46 (29.31)[b]
H_2 : RCH 530	17.03 (24.37)[c]	29.71 (33.03)[c]	37.92 (38.01)[c]	28.22 (31.80)[c]
H_3 : RCH 578	17.28 (24.56)[c]	31.09 (33.89)[c]	39.17 (38.74)[c]	29.18 (32.39)[c]
H_4 : ACH-1155	19.89 (26.49)[d]	35.82 (36.76)[d]	45.39 (42.35)[d]	33.70 (35.20)[d]
H_5 : ACH 155	15.75 (23.38)[b]	26.17 (30.77)[b]	35.18 (36.38)[b]	25.70 (30.18)[b]
H_6 : PCH-5678	19.96 (26.56)[d]	33.89 (35.60)[d]	43.63 (41.34)[d]	32.49 (34.50)[d]
H_7 : Bindaas- 7213	11.58 (19.89)[a]	18.42 (25.42)[a]	26.17 (30.77)[a]	18.72 (25.36)[a]
H_8 : Yuva- 7215	12.54 (20.74)[a]	19.72 (26.36)[a]	28.83 (32.48)[a]	20.36 (26.53)[a]
S. Em (±)	**0.32**	**0.47**	**0.57**	**0.45**
C.D (P=0.05)	**0.96**	**1.41**	**1.75**	**1.37**
C.V (%)	**14.81**	**12.75**	**12.93**	**13.50**
II Interaction (A × B)				
D_1H_1	12.38 (20.60)	22.07 (28.02)	32.14 (34.53)	22.20 (27.72)
D_1H_2	14.04 (22.00)	27.71 (31.76)	34.67 (36.07)	25.47 (29.95)
D_1H_3	14.80 (22.62)	29.09 (32.64)	36.10 (36.93)	26.66 (30.73)
D_1H_4	17.27 (24.56)	31.89 (34.38)	39.15 (38.73)	29.44 (32.56)
D_1H_5	13.18 (21.29)	24.14 (29.43)	31.28 (34.01)	22.87 (28.24)
D_1H_6	16.70 (24.12)	33.81 (35.55)	41.11 (39.88)	30.54 (33.18)
D_1H_7	9.78 (18.22)	16.42 (23.90)	24.33 (29.55)	16.84 (23.89)
D_1H_8	11.13 (19.49)	19.14 (25.94)	26..53 (31.00)	18.93 (25.48)
D_2H_1	16.78 (24.18)	26.07 (30.70)	37.32 (37.65)	26.72 (30.85)
D_2H_2	18.61 (25.56)	31.71 (34.27)	41.18 (39.92)	30.50 (33.25)
D_2H_3	19.29 (26.05)	33.09 (35.12)	43.35 (41.18)	31.91 (34.12)
D_2H_4	22.53 (28.34)	35.89 (36.80)	48.11 (43.91)	35.51 (36.35)
D_2H_5	18.31 (25.33)	28.20 (32.08)	39.08 (38.69)	28.53 (32.03)
D_2H_6	23.07 (28.71)	37.83 (37.96)	52.75 (46.58)	37.88 (37.75)
D_2H_7	13.37 (21.45)	20.42 (26.86)	28.01 (31.96)	20.60 (26.76)
D_2H_8	13.95 (21.93)	23.14 (28.75)	31.12 (33.91)	22.74 (28.20)
F. test	**NS**	**NS**	**NS**	**NS**
S. Em (±)	**1.36**	**2.03**	**1.33**	**1.57**
C.D (P=0.05)	**3.93**	**5.84**	**3.83**	**4.53**
C.V (%)	**14.881**	**12.75**	**12.93**	**13.50**

** Significant @ 5 % DAS: Days after sowing

H: Different *Bt* cotton hybrids: Figures in the parentheses indicate Arc sine transformation Means denoted by same letters in vertical column are not significantly different by DMRT

Table 4: Influence of different dates of *Bt* cotton hybrids on the yield parameters and yield.

Treatment	Good opened bolls/ plants	Bad opened bolls/ plant	Yield (q/ ha)
I Factor A - Sowing dates			
D_1 : Early sowing (20th July, 2019)	39.80[a]	13.46[a]	15.49[a]
D_2 : Late sowing (15th August, 2019)	28.98[b]	17.98[b]	11.82[b]
S. Em (±)	0.72	0.31	**0.34**
C.D (P=0.05)	2.08	0.89	**0.99**
C.V (%)	10.27	9.63	**11.45**
II Factor B - Different *Bt* cotton hybrids			
H_1 : KCH -14K59	36.43[b]	13.62[b]	14.78[b]
H_2 : RCH 530	32.72[c]	16.49[cd]	13.50[cd]
H_3 : RCH 578	31.51[cd]	17.54[d]	12.97[d]
H_4 : ACH-1155	31.39[d]	19.28[e]	10.87[e]
H_5 : ACH 155	35.14[b]	15.23[c]	13.73[c]
H_6 : PCH-5678	28.40[e]	20.79[f]	10.23[e]
H_7 : Bindaas-7213	40.45[a]	10.83[a]	16.99[a]
H_8 : Yuva- 7215	39.07[a]	11.99[a]	16.19[a]
S. Em (±)	0.47	0.43	**0.23**
C.D (P=0.05)	1.41	1.29	**0.70**
C.V (%)	10.27	9.63	**11.45**
II Interaction (A × B)			
D_1H_1	40.93	11.38	16.75
D_1H_2	37.71	14.17	15.30
D_1H_3	37.09	14.96	14.78
D_1H_4	39.61	16.47	12.67
D_1H_5	39.49	12.96	15.51
D_1H_6	34.85	18.02	12.03
D_1H_7	44.98	9.41	18.86
D_1H_8	43.72	10.32	18.05
D_2H_1	31.93	15.86	12.82
D_2H_2	27.73	18.81	11.69
D_2H_3	25.92	20.12	11.17
D_2H_4	23.18	22.09	9.08
D_2H_5	30.78	17.50	11.94

D_2H_6	21.95	23.56	8.42
D_2H_7	35.92	12.25	15.13
D_2H_8	34.41	13.65	14.32
F. test	**NS**	**NS**	**NS**
S. Em (±)	2.04	0.87	**0.97**
C.D (P=0.05)	5.87	2.52	**2.79**
C.V (%)	10.27	9.63	**11.45**

** Significant @ 5 % H: Different *Bt* cotton hybrids
Figures in the parentheses indicate Arc sine transformation
Means denoted by same letters in vertical column are not significantly different by DMRT

CONCLUSIONS

The pink bollworm infestation was found to be lowest in Bindaas-7213 *Bt* cotton hybrid followed by Yuva-7215, whereas a maximum infestation in terms of rosette flowers, locule damage, green boll damage and bad opened bolls was found in PCH-5678 and ACH-1155 *Bt* hybrids at harvest was observed in late sown crop than normal sown crop.

FUTURE SCOPE

The future scope of studying the incidence of pink bollworm (*Pectinophora gossypiella*) on different *Bt* cotton hybrids under different sowing regimes is broad and important for sustainable cotton production. Here are some potential areas of research and development in this field:

1. Hybrid Development: Continued research into the development of *Bt* cotton hybrids with enhanced resistance to pink bollworm is crucial. Scientists can work on creating hybrids that are not only resistant but also have traits that make them more adaptable to different sowing regimes and environmental conditions.

2. Sowing Regime Optimization: Understanding the impact of different sowing regimes (e.g., planting dates, spacing, and density) on pink bollworm infestation is essential. Future studies can explore optimal sowing practices that minimize pest pressure while maximizing cotton yield.

3. Monitoring and Early Detection: Develop innovative monitoring and early detection systems for pink bollworm infestations. This could involve the use of remote sensing technologies, drones, or automated traps to detect and assess pest populations in real-time.

In conclusion, the future scope of studying pink bollworm incidence on different Bt cotton hybrids under various sowing regimes involves a multi-faceted approach that combines genetics, agronomy, technology, and sustainable farming practices. This research is essential for ensuring the long-term viability of cotton production while minimizing the environmental and economic impact of pink bollworm infestations.

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