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Comparative biology of pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) on different *Bt* cotton events

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Abstract

The studies on biology of pink bollworm was carried out under laboratory conditions at Agriculture Research Station, Dharwad farm, University of Agricultural Sciences, Dharwad during 2020-21 and 2021-22 consecutive cropping seasons using different *Bt* cotton events viz., MON 531 (Suraj *Bt*), Fusion *Bt* event (Arjun-21 *Bt*), UASD-78, MON 15985 event (Everest *Bt* and Puli *Bt*), UASD-78 *Bt* HxH-25 and UASD-78 *Bt* HxB-2 and non *Bt* cotton, RAH 100 non *Bt*. The larvae were reared on bolls of different *Bt* cotton genotypes of commercially available events and non *Bt* cotton. Considerable variation in larval period of *Pectinophora gossypiella* (Saunders) on different *Bt* cotton genotypes was recorded. The shortest larval period of 18.53±1.80 days was recorded when the larvae were fed RAH 100 non *Bt*, whereas the longest larval period of 23.92±1.34 days was recorded on Fusion *Bt* event (Arjun-21 *Bt*). Generally, female lived longer than males on all the events. The females fed on RAH 100 non *Bt* laid maximum number of eggs (137.13±14.05 eggs/female) as compared to those on *Bt* cotton (103.02±12.03 eggs/female). The total life cycle of *P. gossypiella* from egg to death of adult varied significantly on different events comprising *Bt* cotton genotypes, which was significantly longer on Fusion *Bt* event (Arjun-21 *Bt*) (47.12±0.43 days) than on RAH 100 non *Bt* (38.35±0.87 days).

Keywords: *Pectinophora gossypiella*, comparative biology, *Bt* cotton genotypes and *Bt* events

Introduction

Cotton is the important commercial crop grown for fiber, fuel and edible oil under diverse agro-climatic conditions. It provides a source of livelihood and employment to millions of farmers, farm workers and persons employed in related industries. In world cotton crop is grown on an area of 33,112.85 thousand hectares with a production of 25,025.83 thousand tones and 755.77 kg/ha productivity. India is the largest producer of cotton in the world accounting about 23 percent of the world total cotton production and is grown on an area of 120.55 lakh hectares with a production of 315.43 lakh bales and 444.82 Kg/ha productivity. (Source: International cotton Advisory Committee, 2021)

The pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) is one of the most important destructive pests of cotton and is distributed throughout the world's cotton growing areas causing maximum seed cotton loss in quantity and quality. Kranthi (2015) [1] reported PBW has developed resistance to both *CryIAc* and *Cry2Ab* endo toxin genes and cotton growers are experiencing severe pink bollworm damage. According to recent study the pink boll worm causing 40 to 95 percent boll infestation in Maharashtra state. PBW is the most destructive pest of cotton in later stages of the crop growth and which leads to 20 to 40 percent of cotton seed yield loss in world.

The recent reports of pink boll worm resistance warrants the development of more potential cotton transgenic events with higher levels of cry toxin expression for sustenance of the transgenic technology. In this direction a new public sector event of UAS, Dharwad, "UASD *Bt* cotton Event No.78" (hence forth referred as UASD-78) has been developed with *CryIAc* gene from ICGEB, New Delhi and has been confirmed to be significantly superior to Mon BG-II for cry toxin expression. The event is in the genetic background of cultivar RAH-100, a released variety belonging to *Gossypium hirsutum* L. RAH-100 characterized with high number of bolls and good regenerative potential is also a good combiner in hybrid development (Patil and Patil, 2003) [3]. The event has completed Bio Safety Research Level-1 trial in line with the regulatory procedures for release of the event. The strength of the event is

proven with various tests including *Cry* protein production in the different parts of plant at different crop growth stages in field trials. The Event-78 needs to be studied to know the efficacy against pink bollworm. To assess this, the following study was carried out to see the survival and development of pink bollworm on different *Bt* cotton events.

Material and Methods

The present studies on comparative biology of pink bollworm was carried out under laboratory condition in Agriculture Research Station, Dharwad farm, University of Agricultural Sciences, Dharwad during 2020-21 and 2021-22 consecutive cropping seasons wherein the larvae were reared on bolls of different *Bt* cotton genotypes of different *Bt* cotton events and non *Bt* cotton *viz.*, MON 531 (Suraj *Bt*), Fusion *Bt* event (Arjun-21 *Bt*), UASD-78, MON 15985 event (Everest *Bt* and Puli *Bt*), UASD-78 *Bt* HxH-25 and UASD-78 *Bt* HxB-2 and non *Bt* cotton, RAH 100 non *Bt* (Table: 1).

The pink boll worm eggs were collected from the laboratory maintained culture and were allowed to hatch. Newly hatched first instar larvae (10 larvae) were kept in separate plastic cup from F1 generation and provided fresh tender bolls (cotton seeds) of UASD Event No-78 and commercial *Bt* events (BG I, BG II and Fusion *Bt*) cotton separately and each treatment was replicated thrice. The duration of different larval instars on *Bt* cotton treatments were monitored to observe the impact of different cotton events on larval instars and the period taken to complete the larval period were recorded instar wise. During pupation, pupae were collected and kept in separate petri dishes individually for recording the pupal period in the respective treatments. Male and female were sexed and reared in a single plastic jar. The jars were closed with muslin cloth and cotton twigs having squares for egg laying. Cotton twigs were replaced every day. The fecundity and survival of male and female adults were recorded on the daily basis. The experiment was terminated after the mortality of males and females moths (Rajput *et al.*, 2019). One day old neonates were released for each treatment (genotypes) and replicated thrice. The observations on the biological attributes *viz.*, incubation period, larval duration, pupal duration, adult longevity of male and female, fecundity, hatching percentage and adult emergence percentage were recorded.

Egg

The incubation period of *P. gossypiella* were calculated based on the duration between the date of egg laying and the emergence of first instar larva. The colour and shape of eggs were also observed.

Fecundity

To assess the total number of eggs laid by an individual female pink bollworm, fresh cotton twig dipped in vial of sucrose solution were kept in plastic jar. The male and females were placed in a cage. Eggs laid by each mated female were counted separately on daily basis and total number of eggs laid during oviposition period of moth was considered as its fecundity.

Larval period

The newly hatched neonate larvae were transferred to plastic cups containing food fresh tender bolls (cotton seeds) of UASD Event No-78 and commercial *Bt* events (BG I, BG II and Fusion *Bt*). The duration from hatching to pre-pupation

were recorded as larval period.

Pupal period

The pupae of pink bollworm were kept in the emergence cage for adult eclosion. The time taken from pre-pupation to adult eclosion was recorded as pupal period.

Adult

Adult emergence (%)

The percent adult emergence of *P. gossypiella* after emergence from pupae was calculated using following formula. The adults moths were also be observed for their colour, shape and size.

$$\text{Adult emergence (\%)} = \frac{\text{Number of adult moth emerged out from pupa}}{\text{Total number of pupae kept}} \times 100$$

Adult longevity

In order to record the observation on adult longevity of *P. gossypiella*, male and female were observed right from the emergence till the mortality of the adult. Thus, male and female longevity were recorded.

Total life cycle

To study the total life cycle of *P. gossypiella* observations were recorded from the date of egg laying to the death of moth when reared on different *Bt* cotton events under laboratory condition.

Results

Biology

The comparative biology of pink bollworm was carried out under laboratory conditions at 27 ± 2 °C during consecutive seasons of *Kharif* 2020-21 and 2021-22 and results of same are presented here in detail.

Incubation period (days)

Eggs were flattened ovals sculptured with longitudinal lines that were white when laid but turned yellowish and then orange red before hatching. They were laid in the axils of petioles, the underside of young leaves, while, in older leaves eggs were laid underside of near the vein junction, or the surfaces of squares and flowers.

The incubation period of PBW eggs ranged from 3.73 to 4.42 days. Significantly higher incubation period 4.42 ± 0.58 days was recorded in RAH 100 non *Bt* which were followed by 4.12 ± 0.66 and 4.25 ± 0.67 days when fed on BG II hybrids, Everest *Bt* and Puli *Bt* respectively. The duration of incubation period was 3.98 ± 0.77 days when fed on MON 531 event (Suraj *Bt*) and the duration of 3.92 ± 0.84 , 3.95 ± 0.92 and 3.88 ± 0.87 days were observed in UASD-78 *Bt* HxH-25, UASD -78 *Bt* HxB-2 and UASD-78 respectively. Comparatively less duration of 3.73 ± 0.76 days was recorded when fed on Fusion *Bt* event (Arjun-21 *Bt*).

Total larval period (days)

First instar larvae were very active and attempted to enter the bolls and fruits as soon as they hatched. They were white with a pale brown head capsule. A total of four instars were observed. As it was an internal borer, it was difficult to document the duration of all four instar therefore, the full larval duration was noted. Total larval period of PBW was ranged from 18.53 to 23.92 days. The shortest total larval duration was recorded in RAH 100 non *Bt* with 18.53 ± 1.80

days which was followed by MON 531 event (Suraj *Bt*) with 21.05 ± 1.26 days. The BG II hybrids Everest *Bt* (HH) and Puli *Bt* (HB) recorded 22.92 ± 2.03 days and 21.90 ± 1.87 days, respectively. Meantime, UASD Event No. 78 events viz., UASD-78, UASD-78 *Bt* HxH-25 and UASD -78 *Bt* HxB-2 recorded 23.63 ± 1.26 , 23.28 ± 1.63 and 22.57 ± 1.51 days, respectively and Fusion *Bt* event (Arjun-21 *Bt*) recorded significantly highest larval duration of 23.92 ± 1.34 days.

Larval weight

The larval weight of PBW when reared on different *Bt* cotton genotypes was presented in Table: 1a and results revealed that significantly minimum larval weight was recorded in Fusion *Bt* event (Arjun-21 *Bt*) with 30.10 ± 2.60 mg followed by UASD-78 (30.70 ± 2.55 mg), UASD-78 *Bt* HxH-25 (31.40 ± 2.02 mg) and UASD -78 *Bt* HxB-2 (31.37 ± 1.62 mg). Whereas, BG II hybrids Everest *Bt* and Puli *Bt* reported 31.63 ± 1.77 and 32.70 ± 1.94 mg of larval weight, respectively. The MON 531 event (Suraj *Bt*) recorded 32.70 ± 1.40 mg which was followed by RAH 100 non *Bt* which recorded maximum larval weight of 33.80 ± 1.83 mg.

Total pupal period (days)

The pupae, which were oval in shape with a pointed tip and initially light brown before turning dark brown, pupated in the bracteoles of *Bt* cotton bolls. In comparison to female pupa, male pupa was smaller in size and distance between the pores on ventral side is less spaced compare to female pupa. The total pupal duration of Fusion *Bt* event (Arjun-21 *Bt*) recorded maximum pupal period of 9.93 ± 0.81 days and it was followed UASD-78 and recorded 9.47 ± 0.68 days. Whereas, UASD-78 *Bt* HxH-25 and UASD -78 *Bt* HxB-2 recorded 9.22 ± 1.16 and 8.93 ± 0.98 days of pupal period were noticed, respectively. Furthermore, the duration of 8.57 ± 0.77 and 8.47 ± 0.84 days were taken to complete pupal period in Everest *Bt* and Puli *Bt*, respectively. In MON 531 event (Suraj *Bt*) the period of pupal duration was found to be 7.93 ± 0.61 days. In RAH 100 non *Bt* comparatively lesser pupal duration of 7.13 ± 1.43 days was observed.

Pupal weight

Significantly minimum larval weight was recorded in Fusion *Bt* event (Arjun-21 *Bt*) with 19.73 ± 1.19 mg followed by UASD-78 (20.00 ± 0.99 mg), UASD-78 *Bt* HxH-25 (21.20 ± 1.93 mg) and UASD -78 *Bt* HxB-2 (22.47 ± 1.18 mg). Whereas, BG II hybrids Everest *Bt* and Puli *Bt* reported 23.00 ± 1.25 and 23.43 ± 1.26 mg of pupal weight, respectively. The BG I MON 531 event (Suraj *Bt*) recorded 23.97 ± 1.56 mg which was followed by RAH 100 non *Bt* which recorded maximum larval weight of 25.13 ± 1.39 mg (Table: 2a).

Adult emergence (%)

Before emerging, pupae turned a dark brown colour, indicating that adults will emerge shortly. Significantly minimum adult emergence percentage was recorded in Fusion *Bt* event (Arjun-21 *Bt*) with 69.33 ± 4.04 percent followed by UASD-78 ($70.50 \pm 1.80\%$) Whereas, UASD Event No. 78 based hybrids UASD-78 *Bt* HxH-25 recorded 73.33 ± 3.06 percent and UASD -78 *Bt* HxB-2 reported 74.33 ± 2.31 percent. The BG II hybrids Everest *Bt* and Puli *Bt* recorded 76.83 ± 2.02 and 82.00 ± 1.80 percent, respectively. BG I MON 531 event (Suraj *Bt*) recorded 87.33 ± 2.52 percent. The highest adult emergence percentage was noticed in RAH 100 non *Bt*

with 91.50 ± 0.87 percent.

Fecundity

The mean number of eggs laid by individual female reported that the lower fecundity of 103.02 ± 12.03 eggs/female were observed in Arjun-21 *Bt* followed by UASD-78, UASD-78 *Bt* HxH-25 and UASD -78 *Bt* HxB-2 with recording 106.28 ± 12.58 , 104.52 ± 11.58 and 109.80 ± 10.81 eggs per female respectively. Further, the BG II hybrids recorded 115.35 ± 11.89 (Everest *Bt*) and 119.02 ± 14.14 (Puli *Bt*) eggs per female while MON 531 event (Suraj *Bt*) reported 120.63 ± 12.32 eggs per female. The highest fecundity was noticed in case of RAH 100 non *Bt* (137.13 ± 14.05 eggs/female).

Egg hatchability (%)

Significantly minimum egg hatching percentage was recorded in Fusion *Bt* event (Arjun-21 *Bt*) with 67.00 ± 0.87 percent followed by UASD-78 ($71.67 \pm 0.58\%$) Whereas, UASD Event No. 78 based hybrids UASD-78 *Bt* HxH-25 recorded 72.17 ± 1.04 percent and UASD -78 *Bt* HxB-2 reported 72.66 ± 1.32 percent. The BG II hybrids Everest *Bt* and Puli *Bt* recorded 76.83 ± 2.02 and 80.33 ± 1.61 percent, respectively. BG I MON 531 event (Suraj *Bt*) recorded 84.33 ± 0.58 percent. The highest egg hatching percentage was noticed in RAH 100 non *Bt* with 92.33 ± 1.15 percent (Table: 2b).

Adult longevity (male)

Male moth was comparatively smaller than female moth and adults were sexed by observing the abdominal genital character and shape. The longest male period of 8.30 ± 0.75 days was noticed in Fusion *Bt* event (Arjun-21 *Bt*) followed by 8.17 ± 0.65 , 8.03 ± 0.81 and 7.97 ± 0.56 days in UASD-78, UASD-78 *Bt* HxH-25 and UASD -78 *Bt* HxB-2 respectively. Whereas, BG II hybrids, Everest *Bt* and Puli *Bt* reported 7.77 ± 0.62 and 7.63 ± 0.67 days of male longevity, respectively. Further, the MON 531 event (Suraj *Bt*) recorded 7.57 ± 0.68 days and the shortest period of 7.43 ± 0.88 days was noticed in RAH 100 non *Bt*.

Adult longevity (female)

The adult moth was grayish brown with blackish bands on the forewings and the hind wings were silvery grey (Plate: 1). The longest female period of 9.53 ± 0.94 days was observed in Fusion *Bt* event (Arjun-21 *Bt*) followed by 9.33 ± 0.75 , 8.93 ± 0.48 and 8.80 ± 0.33 days in UASD-78, UASD-78 *Bt* HxH-25 and UASD -78 *Bt* HxB-2 respectively. Whereas, BG II hybrids, Everest *Bt* and Puli *Bt* reported 8.60 ± 0.56 and 8.47 ± 0.54 days of female longevity, respectively. Further, the BG I MON 531 event (Suraj *Bt*) recorded 8.40 ± 0.58 days and the shortest period of 8.27 ± 0.48 days was noticed in RAH 100 non *Bt*.

Total life cycle (male)

The longest period of 45.88 ± 0.63 days was noticed in Arjun-21 followed by 45.15 ± 0.56 , 44.45 ± 0.09 and 43.42 ± 0.40 days in UASD-78, UASD-78 *Bt* HxH-25 and UASD -78 *Bt* HxB-2 respectively. Whereas, BG II hybrids, Everest *Bt* and Puli *Bt* reported 43.37 ± 0.63 and 42.25 ± 0.66 days of male longevity, respectively. Further, the MON 531 event (Suraj *Bt*) recorded 40.53 ± 0.95 days and the shortest period of 37.52 ± 0.88 days was noticed in RAH 100 non *Bt*.

Total life cycle (female)

The longest period of 47.12±0.43 days was noticed in Arjun-21 *Bt* followed by 46.32±0.68, 45.35±0.23 and 44.25±0.26 days in UASD-78, UASD-78 *Bt* HxH-25 and UASD -78 *Bt* HxB-2, respectively. Whereas, BG II hybrids, Everest *Bt* and

Puli *Bt* reported 44.29±0.76 and 43.08±0.65 days of female longevity, respectively. Further, the MON 531 event (Suraj *Bt*) recorded 41.37±0.83 days and the shortest period of 38.35±0.87 days was noticed in RAH 100 non *Bt*.

Table 1: Treatment details (Different *Bt* cotton events and non *Bt* cotton variety)

Sl. No.	Genotypes	Type of genotype	Transgenic event	Source
1	UASD-78	Variety	UASD Event No.78	UAS, Dharwad
2	UASD-78 <i>Bt</i> HH-25	H × H		
3	UASD-78 <i>Bt</i> HB-2	H × B		
4	Suraj BG-I	Variety	BG-I (Mon 531)	CICR, Nagpur
5	Everest BG-II	H × H	BG-II (Mon 15985)	BIOSEED
6	Puli BG-II	H × B		
7	RAH-100 non <i>Bt</i>	non <i>Bt</i> (Variety)	non- <i>Bt</i>	UAS, Dharwad
8	Arjun-21 (Fusion <i>Bt</i>)	H × H	GFM	Nath seeds

Table 2a: Biology of *P. gossypiella* on different *Bt* cotton events and non *Bt* cotton

Sl. No.	Genotypes	Transgenic Event	TLP (days)	LW (mg)	TPP (days)	PW (mg)	AE (%)
1	UASD-78	UASD Event No-78	23.63±1.26	30.70±2.55	9.47±0.68	20.00±0.99	70.50±1.80
2	UASD-78 <i>Bt</i> HxH-25		23.28±1.63	31.40±2.02	9.22±1.16	21.20±1.93	73.33±3.06
3	UASD-78 <i>Bt</i> HxB-2		22.57±1.51	31.37±1.62	8.93±0.98	22.47±1.18	74.33±2.31
4	Suraj BG-I	MON 531	21.05±1.26	32.70±1.40	7.93±0.61	23.97±1.56	87.33±2.52
5	Everest BG-II	MON 15985	22.92±2.03	31.63±1.77	8.57±0.77	23.00±1.25	76.83±2.02
6	Puli BG-II		21.90±1.87	32.70±1.94	8.47±0.84	23.43±1.26	82.00±1.80
7	RAH-100 non <i>Bt</i>	Non <i>Bt</i>	18.53±1.80	33.80±1.83	7.13±1.43	25.13±1.39	91.50±0.87
8	Arjun -21 (Fusion <i>Bt</i>)	GMF	23.92±1.34	30.10±2.60	9.93±0.81	19.73±1.19	69.33±4.04
S. Em. (±)			0.27	0.53	0.13	0.46	1.42
CD (P=0.05)			0.83	1.62	0.40	1.41	4.31
CV (%)			2.13	2.92	2.64	3.63	3.15

TLP- Total larval period, LW- Larval weight, TPP- Total pupal period, PW- Pupal weight, AE- Adult emergence

Table 2b: Biology of *P. gossypiella* on different *Bt* cotton events and non *Bt* cotton

Sl. No.	Genotypes	F/F (numbers)	HIG (%)	IP (days)	AL (days)		TLC (days)	
					M	F	M	F
1	UASD-78	106.28±12.58	71.67±0.58	3.88±0.87	8.17±0.65	9.33±0.75	45.15±0.56	46.32±0.68
2	UASD-78 <i>Bt</i> HxH-25	104.52±11.58	72.17±1.04	3.92±0.84	8.03±0.81	8.93±0.48	44.45±0.09	45.35±0.23
3	UASD-78 <i>Bt</i> HxB-2	109.80±10.81	72.66±1.32	3.95±0.92	7.97±0.56	8.80±0.33	43.42±0.40	44.25±0.26
4	Suraj BG-I	120.63±12.32	84.33±0.58	3.98±0.77	7.57±0.68	8.40±0.58	40.53±0.95	41.37±0.83
5	Everest BG-II	115.35±11.89	76.83±2.02	4.12±0.66	7.77±0.62	8.60±0.56	43.37±0.63	44.20±0.76
6	Puli BG-II	119.02±14.14	80.33±1.61	4.25±0.67	7.63±0.67	8.47±0.54	42.25±0.66	43.08±0.65
7	RAH-100 non <i>Bt</i>	137.13±14.05	92.33±1.15	4.42±0.58	7.43±0.88	8.27±0.48	37.52±0.88	38.35±0.87
8	Arjun -21 (Fusion <i>Bt</i>)	103.02±12.03	67.00±0.87	3.73±0.76	8.30±0.75	9.53±0.94	45.88±0.63	47.12±0.43
S. Em. (±)		2.41	0.71	0.11	0.13	0.15	0.37	0.36
CD (P=0.05)		7.30	2.16	0.33	0.39	0.45	1.13	1.10
CV (%)		3.65	1.60	4.7	2.86	2.97	1.52	1.44

F/F- Fecundity per female, HIG- Hatching in next generation, IP- Incubation period, AL- Adult longevity, M- Male, F- Female, TLC- Total life cycle

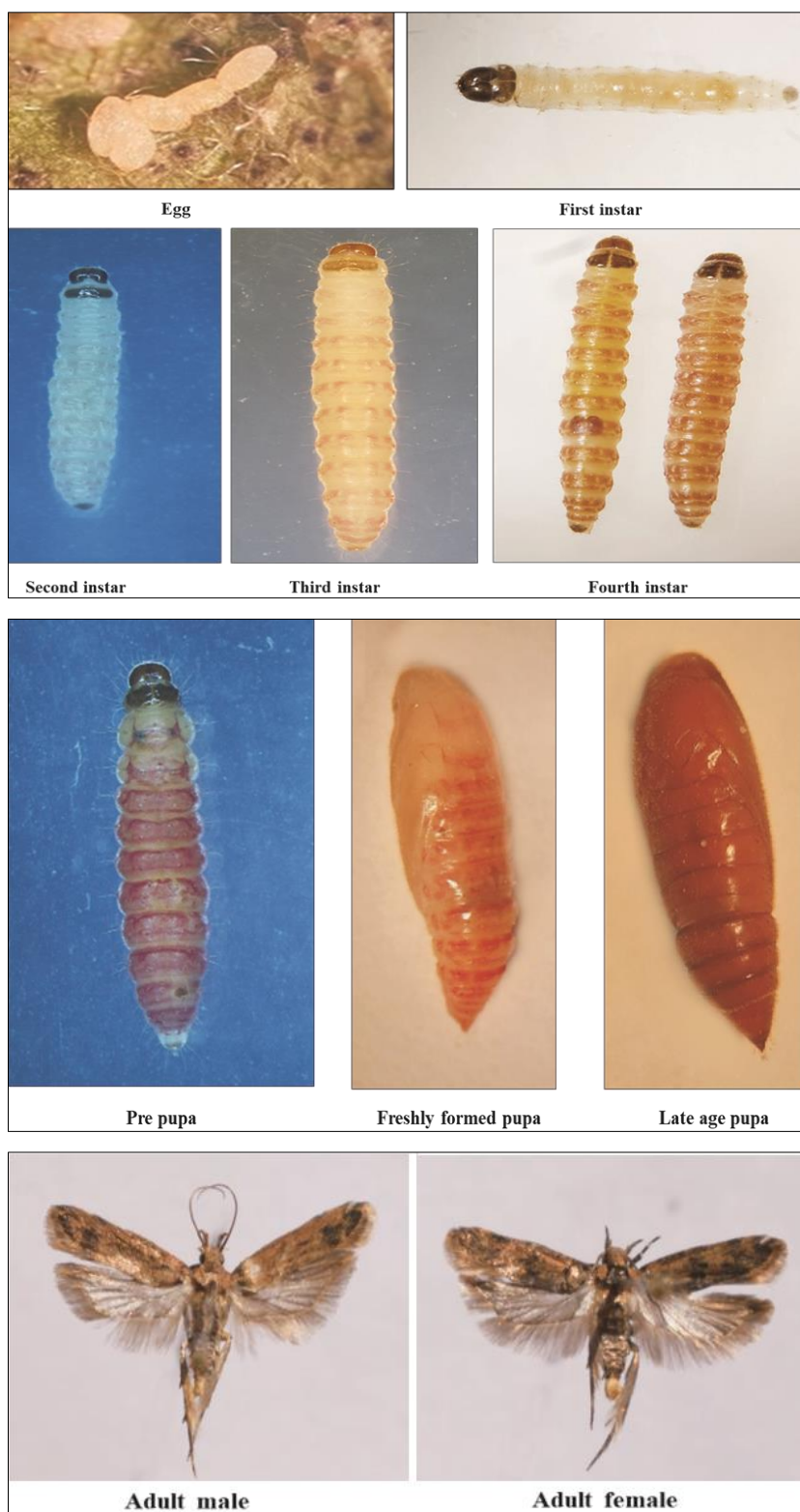


Plate: 1 Different life stages of pink bollworm

Discussion

The incubation period of eggs was minimum when reared on *Bt* transgenic event and longest on non *Bt* cotton. Among the different events tested Fusion *Bt* event (Arjun-21 *Bt*) affected egg period by recording 3.73 ± 0.76 days whereas it was 4.42 ± 0.58 days when reared on RAH 100 non *Bt*. Shrinivas *et al.* (2019) [6] revealed that incubation period was 3.81 ± 0.10 days on *Bt* cotton. Whereas, Zinzuvadiya *et al.* (2017) [7] reported that the egg period of pink bollworm was 4.9 ± 0.99 days when reared on artificial diet.

Considerable variation was recorded in larval period of *P. gossypiella* feeding on different events. The shortest total larval duration was recorded in RAH 100 non *Bt* with 18.53 ± 1.80 days and longest on Fusion *Bt* event (Arjun-21 *Bt*) recorded significantly highest larval duration of 23.92 ± 1.34 days. The results are close proximity with Shrinivas *et al.* (2019) [6] who observed that larval period was in a range of 22.5 to 28.5 days with the mean of 26.1 ± 0.66 days. The larval and pupal weight was affected when reared on *Bt* cotton events as compared to non *Bt*. The weight of pupae was

significantly reduced on all *Bt* cotton genotypes of different events compared to RAH 100 non *Bt* cotton. The mean pupal weight of *P. gossypiella* reared on bolls of *Bt* cotton hybrids of different events at 120 days old crop is consistent with the findings of Likhitha (2017) [2], who reported that rearing of early instar larvae of *P. gossypiella* on bolls of *Bt* cotton hybrids of different events produced malformed pupae with the lower pupal weight.

The larvae feeding on bolls of *Bt* cotton genotypes of different events revealed lower weight as compared to non *Bt* cotton. The Fusion *Bt* event (Arjun-21 *Bt*) was less palatable to *P. gossypiella* as the larval weight was very less compared to other *Bt* and non *Bt* cotton. The present findings are in accordance with Likhitha (2017) [2], who reported that the larval weight of *P. gossypiella* was found to be lowest on all *Bt* cotton genotypes of different events compared to non *Bt* cotton. Similarly the maximum adult emergence (99.33 percent) was registered in first instar larvae when fed on bolls of NCEH-34 non *Bt* cotton hybrid. When fed on the NCS-207 BG-II bolls, the *P. gossypiella* first instar larvae recorded the lowest adult emergence rates.

The shortest pupal period of 7.13 ± 1.43 days was observed of RAH 100 non *Bt* while pupal period was 9.93 ± 0.81 days on Fusion *Bt* event (Arjun-21 *Bt*). The current findings are in close proximity with Shrinivas *et al.* (2019) [6] who observed that pupal period was ranged from 7.50 to 9.50 days with mean value of 8.43 ± 0.18 days. Although male longevity did not follow a fixed trend, the minimum adult male longevity of *P. gossypiella* was recorded as 7.43 ± 0.88 days on RAH 100 non *Bt* cotton and the maximum longevity as 8.30 ± 0.75 Fusion *Bt* event (Arjun-21 *Bt*).

Various workers have reported the fecundity of *P. gossypiella* females, Shrinivas *et al.* (2019) [6] reported it to be 103.8 ± 16.14 in a range of 95 to 175 eggs. Zinzuvadiya *et al.* (2017) [7] reported fecundity of PBW females to be 110.6 eggs per individual. In the present study host plant exerted significant effect on egg laying capacity of females fed on different *Bt* cotton events. The maximum number of eggs was laid by females that were fed on RAH 100 non *Bt* cotton (137.13 ± 14.05 eggs) as larvae followed by those fed on Fusion *Bt* event (Arjun-21 *Bt*) (103.02 ± 12.03 eggs).

Total life cycle of pink bollworm from egg to death of adult varied on different *Bt* cotton events, which was significantly longer on Fusion *Bt* event (Arjun-21 *Bt*) (47.12 ± 0.43 days) than 38.35 ± 0.87 days on RAH 100 non *Bt* cotton. The results were supported by Shrinivas *et al.* (2019) [6] who reported that the total life cycle was 46.82 ± 1.20 days within the range of 40 to 55 days when reared on *Bt* cotton.

In the present study, a noteworthy difference between the male and female adult longevity when reared on *Bt* and non *Bt* cotton was observed. Females grown on non *Bt* cotton produced noticeably more eggs as compared to those bred on *Bt* cotton. Larval development duration was likewise considerably varied between the treatments. The maximum pupal duration was calculated in the meantime using *Bt* cotton events. *Bt* cotton reduced the fecundity of egg laying. The current study supported the impacts of *Bt* cotton events and non-*Bt* cotton on various stages of the pink bollworm's life cycle. This study therefore proved that the *Bt* cotton containing *CryIAc* gene had negative impacts on all stages of pink bollworm biology.

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