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## Incidence of pink bollworm *Pectinophora gossypiella* Sanders in different agro-ecological zones of Karnataka

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### Abstract

Roving surveys were conducted to know the incidence of pink bollworm in *Bt* cotton during *kharif*-2017-18 and 2018-19 in different agro-ecological zones of Karnataka. The level of incidence was recorded twice during the season *i.e.* at flowering and boll development stages. Widespread infestation of pink bollworm on *Bt* cotton across Karnataka was observed with a range of 20–85% in both the years. A typical pattern of progressive increase in the level of pink bollworm infestation and intensification of locular damage with the advancement of the crop season was evident. Raichur recorded highest no of larvae/50 bolls, green boll and locule damage (72.74, 58.50, 72.84% in 2017-18 and 42.78, 61.00, 62.69% in 2018-19). Relatively less damage was recorded from Mysuru with 6.48% flower damage in 2017-18 and 4.20% in 2018-19, 70.35% green boll damage in 2017-18 and 37.02 percent in 2018-19, 68.20% and 42.74% locule damage in 2017-18 and 2018-19 respectively. Least percent of flower damage recorded from Uttara Kannada *i.e.* 1.48%, 0.97% in 2017-18 and 2018-19 respectively, followed by Shivamogga and Chitradurga. Least locule damage was recorded from Uttara Kannada during both the years (19.96%, 12.89%), followed by Shivamogga (35.45%, 30.22%) and Chitradurga (38.50%, 30.72%). Average flower, boll and locule damage under rainfed condition was 1.46, 32.92 and 41.93% whereas, it was 4.23, 40.78 and 48.07%, under irrigated condition, respectively. None of the districts had any infestation below ETL.

**Keywords:** Incidence, pink bollworm, Karnataka

### Introduction

Cotton (*Gossypium* spp.) belongs to the family malvaceae is a major commercial crop grown in 111 countries. China, India and the United States are the leading cotton-producing countries. India cultivates more than 11 million hectares annually and is the largest area in the world. The exact area under *Bt* cotton in 2019 was 12.58 4 m ha with production of 360.00 lakh bales and yield accounting 486 kg/ha [1].

The pink bollworm, *Pectinophora gossypiella* (Saunders) was described by W.W. Saunders in 1843 as *Depressaria gossypiella* from specimens found to damaging cotton in India. The insect has its origin from Indo-Pak region [2]. And is widely distributed throughout tropical America, Africa, Asia, Australia, Egypt, USA and Mexico, wherever cotton is grown [3]. The nativity of pink bollworm is said to be Southern Asia and potentially India with wild and cultivated cottons of the region as hosts as per the conclusions over a serious debates. It is a stenophagous pest which has coevolved with malvaceous food plants like cotton, okra, deccan hemp and roselle [4]. Interestingly, Saunders stated that, American cotton variety (*Gossypium hirsutum*) was obviously susceptible compared to India's indigenous cottons *G. arboreum* and *G. herbaceum*, with little doubt, had long been associated with this pest and had developed some degree of resistance.

To counter resistance problem, *Bt* transgenic genotypes were commercialized, for the first time during 1996 in USA and 2002 in India. This insect was not a severe issue in India about 30 years ago. There have been very few reports of any significant harm to cotton from pink bollworm in the nation since 1982. The suppression of bollworms is a great success in India until the survival reports of pink bollworm during 2009. Later wide spread resistance noticed in Gujarat, Andhra Pradesh, Maharashtra and parts of Karnataka. In this framework, we aimed at documenting widespread field level infestation of PBW in *Bt* cotton from different agro-ecological zones of Karnataka, which holds area of 5.46 lakh ha area, 18 lakh bales of production and 560.44 kg/ha productivity [5].

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## Materials and Methods

### Sampling location

Roving surveys were conducted in different districts viz., Bagalakote, Ballari, Belagavi, Chitradurga, Davanagere, Dharwad, Gadag, Haveri, Kalaburgi, Mysuru, Raichur, Shivamogga, Uttara Kannada and Vijayapura districts of Karnataka. The surveys were done twice in the season, first during flowering and second during peak boll formation stage. The sampling procedure accounted for the various parameters like rosetted flowers, green bolls, opened bolls and number of locules damaged for assessing the dynamics and severity of PBW damage during different stages. For assessment of the green boll damage due to PBW, destructive sampling was done of about 50–60 green bolls collected randomly from a unit area of one acre at each location. The care was taken while sampling green bolls, that a single boll was sampled from each plant so as to collect more representative sample of the population. The numbers of infested bolls recorded and converted to percent infestation. Green bolls collected from field were split open to record the live (second instar on words) pink bollworm larval incidence.

### Observations recorded

Village name, GPS co-ordinates, Bt cotton or non Bt cotton, name of the variety/hybrid and crop type (irrigated/rainfed).

### Flower damage (%)

The incidence of pink bollworm larvae would be recognized by rosetted flower on cotton; hence flower rosetting was observed by counting the total of number of flowers in ten plants and the number of rosette flowers amongst them. Data was presented as percent rosette flower.

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

### Green bolls damage (%)

Twenty green bolls were randomly plucked from the ten tagged plants to know the incidence of pink bollworm. The green boll damage was calculated using the formula given below and converted to percentage.

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

### Larval population

Twenty randomly plucked bolls were carefully examined in the laboratory, for the presence of PBW larvae

### Locule damage (%)

Samples analyzed for total number of locules and damaged locules due to PBW in twenty bolls and expressed in terms of percent locule damage.

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

## Result and Discussion

### 2017-18

The results of roving surveys conducted during September-December, 2017 in cotton growing areas of Karnataka

indicated a progressive increase in PBW incidence from flowering stage to boll bursting. The mean rosetted flower ranged between 1.48 (Uttara Kannada) to 6.50 (Mysuru) per cent as indicated in Table 1. Apart from Mysuru district, the infestation was more in Raichur (6.31), Kalaburgi (6.24) Ballari (6.18) and Haveri (5.93). Least flower damage was recorded from Uttara Kannada 1.48 per cent followed by Shivamogga (2.34%) and Chitradurga (2.45%). Village wise highest incidence noticed in Beguru (6.72%) of Mysuru and least in Mundgod (1.39%). The highest green boll infestation was observed in Raichur (72.74%) followed by Mysuru (70.35%), wherein the infestation levels in randomly sampled green bolls were found consistently above 30 per cent in all the districts except Uttara Kannada (11.26%). The larval load was highest in the green bolls collected from Raichur (58.50 larvae/50 bolls). Whereas, Mysuru and Kalaburgi recorded 54.00 and 53 larvae/50 bolls next to Raichur.

The data on locule damage was reasonably correlated with the high levels of green boll infestation and no of larval population (per 50 bolls) in corresponding districts having higher larval incidence. More than 30 per cent of the locule damage was found by PBW in all districts; except Uttara Kannada which had 19.96 percent locule damage. Over all the state mean flower damage, green boll damage, no of larvae per 50 bolls and locule damage during 2017-18 was 4.65, 42.42, 41.68 and 50.45 per cent respectively.

### 2018-19

The trend in infestation pattern of PBW during 2018-19 followed preceding season is same except in Mysuru. The flower damage ranged 0.97 to 5.97 per cent and mean rosetted flower damage was 3.51 per cent. The per cent flower damage, green boll damage no. of larvae and locule damage appeared to be highest in Raichur (5.97%, 42.78%, 61/50 bolls, 62.69%), followed by Kalaburgi and Ballari (Table 2). Unlike previous year Mysuru recorded 4.20 per cent flower damage, 37.05 per cent green boll damage with 43 larvae/50 bolls and 42.75 per cent locule damage. Such variation was due to cotton ratooning practiced 2017-18 and not in the year 2018-19. Whereas, Uttara Kannada district had flower damage of only 0.97 per cent, green boll damage of 10.49 per cent with 9 larvae/50 bolls and 12.89 per cent locule damage followed by slightly higher incidence in Shivamogga, Gadag and Bagalakote districts.

### Pooled observations

The pooled observation depicted that the highest mean per cent flower damage was from Raichur (6.14) followed by Kalaburgi (5.82), Ballari (5.68) and Mysuru (5.34). The green boll damage ranged between 10.87 to 57.76 per cent. Kalaburgi district recorded 50.64 per cent damage followed next to Mysuru (53.68%) and Raichur (57.76%) districts. Shivamogga recorded 27.86 per cent boll damage after Uttara Kannada (10.87%) on the lower incidence side. Locule damage was highest (67.05%) in Raichur district followed by Kalaburgi (62.05%), Ballari (57.34%), Mysuru (55.47%) and Haveri (54.93%). Whereas, the least infestation reported from Uttara Kannada (16.42%), Shivamogga (32.82%), Chitradurga (34.62%) as mentioned in Table 3.

A excerpt of PBW infestation over two season (2017-18 and 2018-19) has been prepared as precounted in Table 3. Considering pooled data highest damage by PBW to flowers (6.23%) was observed in the village of Sathanarayana camp of Raichur district. Similarly green boll damage was highest

in Sathyanarayana camp (56.63%) of Raichur district. The locule damage appeared to be highest (68.13%) in the Kurdi village of Raichur district. It indicated Flower damage due to PBW was below ETL in all the districts. But none of the districts had any green boll damage and locule damage below ETL (Table 4). All the districts except Mysuru and Raichur fall under moderate infestation zones/areas with infestation level of 20-50 per cent boll damage. Whereas, Uttara Kannada comes under a low infestation zone with respect to locule damage. Bagalakote, Vijayapura, Kalaburgi, Gadag, Davanagere, Shivamogga and Chitradurga fall under moderate infestation areas (20-50%). Dharwad, Belagavi, Mysuru, Ballari, Raichur and Haveri districts falls under high infestation zone/areas (>50%). These results are in line with the studies of Dhurua and Gujar (2011) [6] who reported the infestation in non-Bt cotton ranged from 0 to 2.1 pink bollworm larvae boll and infestation ration ranged from 0.00-85.00 per cent. In the population of Guntur, Adilabad, Rajkot and Delhi they were reported the infestation ratio of 76, 80, 4.8 and 66 per cent with 1.1, 1.2, 0.1 and 0.90 larvae per boll. Further more in line with reports of (Kranthi, 2015) [7], Khuhro *et al.* (2015) [8] and Abbas *et al.* (2016) [9].

Irrespective of locations irrigated crop suffered more infestation due to PBW compared with rainfed crop. Flower damage, boll damage, larval incidence and locule damage in irrigated crop was 4.23 per cent, 40.78 per cent, 40.94 larvae/50 bolls and 48.07 per cent respectively (Table 5), which is supported by [10] who recorded PBW damage only in the irrigated cotton fields, but not in the rainfed cotton fields in Yavatmal district, which is one of the major cotton growing districts in Maharashtra.

Further, irrespective of locations intraspecific (H×H) hybrids recorded least infestation with respect to interspecific hybrids (H×B) hybrids (Table 6). H×H hybrids showed a significant difference in boll damage, larval incidence and locule damage compared with H×B hybrids in both the seasons. Flower damage recorded from H×H hybrids was 4.49 per cent, 3.47 per cent in 2017-18 and 2018-19 respectively. Green boll damage was 40.79 percent and larval incidence/50 bolls was 40.75 with 49.32 per cent locule damage in 2017-18. While, Intraspecific hybrids recorded 5.04 per cent flower damage, 46.52 per cent boll damage, 44.01 larvae/50 bolls and 53.29 per cent locule damage in 2017-18. Further in the season 2018-19 H×H hybrids recorded 3.47 per cent flower damage, 32.72 per cent green boll damage, 35.95 larvae/50 bolls and 41.72 per cent locule damage. H×B hybrids recorded 3.61, 34.86, 37.88 and 47.74 per cent of flower, boll, no of larvae/50 bolls and locule damage respectively.

Pooled data indicated the significant difference in per cent infestation of PBW in H×H hybrids relative to H×B hybrids. 3.98 per cent flower damage, 37.33 per cent green boll

damage, 38.35 larvae/50 bolls and 45.54 per cent locule damage observed in intraspecific hybrids. Whereas, interspecific hybrids accounted for 4.33, 39.61, 40.94, 47.24 per cent of flower damage, boll damage, no. of larvae/50 bolls and locule damage respectively.

### Conclusion

This field study indicated that the damage to Bt. cotton plants was very high presently across Karnataka, and was not influenced by cultural practices like irrigation, and the hybrids cultivated. The failure of Bt cotton in reducing PBW populations, and the near absence of other bollworm species, has, perhaps, created a vacant niche for the PBW, thus allowing it to build pestiferous populations. Over reliance and wide spread cultivation of Bt genotypes over many years has created lot of selection pressure on PBW, thus leading to resistance development. Besides, PBW do not have an alternate/ alternative host in practical sense. Poor compliance of refugia is also said to synergise the resistance development of PBW against Cry toxins. Presently no much chemical control means are significant. Therefore, it is suggested that integrated pest management practices would be ideal in PBW management.

There exists very few published reports documenting PBW resistance to first generation Bt cotton *i.e.* Bollgard carrying single gene Cry1Ac in India. The diet incorporation bioassay studies carried out by [11] on a field population of PBW collected from Gujarat State during cotton season of 2008 revealed the development of resistance to Bt toxin Cry1Ac. The mutations in a gene encoding a cadherin protein that binds Bt toxin Cry1Ac have been reported to be associated with field-evolved resistance of PBW to Cry1Ac produced by transgenic cotton in India [12]. Although enough attention had already been paid towards the issue of comeback and successful feeding and survival of PBW on dual gene Bt cotton *i.e.* Bollgard II in India through popular articles [13], technical bulletins [14, 15]. One cannot neglect the very possibility that the pest that had broken out seriously in one part of the country may also pose severe threat to the other parts in due course of time causing havoc [3]. Therefore, we feel this is the right time to alert the stakeholders of cotton production on the seriousness of the issue and to devise strategies and policies appropriate for the effective and eco-friendly management of this serious pest of cotton. In this perspective we presented, through extensive surveying and repetitive sampling at various growth stages of cotton crop, a detailed picture of PBW infestation levels in various zones of Karnataka. The knowledge generated in present study will be crucial in getting deeper insights into the dimensions of PBW infestations that may help in assessing the potential yield losses in cotton crop.

**Table 1:** Incidence pattern of pink bollworm *Pectinophora gossypiella* Sanders in Karnataka (2017-18)

Districts/Villages	GPS co-ordinates	Genotypes	Irrigated/Rainfed	Rosetted flowers (%)		Green boll damage (%)		No of larvae /50 bolls		Locule damage (%)		
Bagalakote	Kittli	15.51.31.N 75.32.54E	Jadoo (H×H)	Irrigated	3.48	4.28	33.34	34.28	36.00	37.00	41.02	40.19
	Kelur	15.58.42.N 75.42.27E	Jadoo (H×H)		5.07		35.22		38.00		39.35	
Ballari	Rampura	14.89.15N 76 78 92E	Bullet (H×H)	Irrigated	6.00	6.18	49.78	50.36	53.00	52.50	59.50	60.50
	Dasapura	14.95.66N 76 82.93E	Challenge (H×B)		6.35		50.94		52.00		61.49	
Belagavi	Saundatti	15.42.28N 75.04.39E	Jadoo (H×H)	Rainfed	5.67	5.20	40.85	39.89	45.00	43.00	56.20	55.06
	Vakkunda	15.46.26N 74.53.26E	Jadoo (H×H)		4.72		38.92		41.00		53.92	
Chitradurga	Kurudihalli	14.16.25N 76.34.07E	Bahubali (H×B)	Irrigated	2.65	2.45	31.27	31.62	32.00	30.00	37.14	38.50
	Nandanahalli	14.16.44N 76.35.02E	Bullet (H×H)		2.24		31.97		28.00		39.85	
Davanagere	Hebbalu	14.22.46N 76.05.15E	Yuva (H×B)	Irrigated	4.91	4.56	38.01	38.52	42.00	39.00	52.67	53.51
	Kanivebilachi	14.10.11N 75.50.63E	First class (H×H)		4.21		39.03		36.00		54.35	
Dharwad	Govinakoppa	15.28.02N 75.05.42E	Bunny (H×H)	Rainfed	5.48	5.42	43.15	42.19	50.00	51.00	56.71	56.28

	Byahatti	15.26.38N 75.12.06E	First class (H×H)		5.36		41.22		52.00		55.84	
Gadag	Venkatapura	15.21.01N 75.51.17E	ATM (H×H)	Rainfed	4.04	3.79	32.36	32.19	33.00	34.50	37.68	38.96
	Timmlapura	15.17.42N 75.84.62E	Jadoo (H×H)		3.53		32.01		36.00		40.24	
Haveri	Devihosur	14.48.09N 75.19.28E	Neeraj (H×B)	Rainfed	5.72	5.93	49.05	49.76	50.00	52.00	57.97	58.83
	Kabbur	14.44.24N 75.19.52E	MRC-7351 (H×B)		6.13		50.46		54.00		59.68	
Kalaburgi	Taranahalli	17.12.16N 77.16.28E	RCH-569(H×H)	Irrigated	6.29	5.93	53.66	52.67	50.00	53.00	62.35	64.62
	Hosalli	17.09.58N 77.14.00E	ATM (H×H)		6.35		51.67		56.00		66.89	
Mysuru	Taggluru	11.56.09N 76.40.16E	Minarva (H×B)	Irrigated	6.24	6.48	71.03	70.35	55.00	54.00	67.12	68.20
	Begur	11.55.01N 76.39.55E	Bahubali (H×B)		6.72		69.67		53.00		69.27	
Raichur	Sathyaranyana camp	16.27.36N 77.21.70E	Jadoo (H×H)	Irrigated	6.57	6.31	72.25	72.74	62.00	58.50	73.32	72.84
	Kurdi	16.08.25N 77.20.81E	Jadoo (H×H)		6.04		73.22		55.00		72.36	
Shivamogga	Anvatti	14.55.03N 75.15.30E	Flux (H×H)	Irrigated	2.15	2.34	30.00	30.97	29.00	30.00	31.05	35.45
	Sominakoppa	14.01.03N 75.37.11E	Frist class (H×H)		2.52		31.94		31.00		39.84	
Uttara Kannada	Mundgodu	14.97.36N 75.04.06E	Yuva (H×H)	Rainfed	1.39	1.48	10.92	11.26	10.00	12.00	18.94	19.96
	Nandikatta	15.02.41N 74.59.36E	Super fiber (H×B)		1.57		11.59		14.00		20.97	
Vijayapura	Bibi.Ingalagi	16.38.30N 76.14.30E	Shabari (H×H)	Irrigated	4.06	4.34	37.85	37.15	36.00	37.00	44.88	43.48
	Hanchali	16.39.09N 76.13.36E	Bunny (H×H)		4.62		36.45		38.00		42.07	
Mean					4.65		42.42		41.68		50.45	

**Table 2:** Incidence pattern of pink bollworm *Pectinophora gossypiella* Sanders in Karnataka (2018-19)

Districts/Villages		GPS co-ordinates	Genotypes	Irrigated /Rainfed	Rosetted flowers (%)	Green boll damage (%)	No of larvae /50 bolls	Locule Damage (%)			
Bagalakote	Kittli	15.51.31.N75.32.54.E	Jadoo (H×H)	Irrigated	2.18	2.22	32.06	34	32.00	34.08	35.14
	Kelur	15.58.42.N75.42.27.E	Jadoo (H×H)		2.26		30.86			30	
Ballari	Rampura	14.89.15N 76 78 92E	Bullet (H×H)	Irrigated	5.24	5.19	41.87	46	48.00	56.00	54.19
	Dasapura	14.95.66N 76 82.93E	Challenge (H×B)		5.13		39.48			50	
Belagavi	Saundatti	15.42.28N 75.04.39E	Jadoo (H×H)	Rainfed	3.56	3.44	32.00	38	40.00	51.51	52.45
	Vakkunda	15.46.26N 74.53.26E	Jadoo (H×H)		3.31		41.85			42	
Chitradurga	Kurudihalli	14.16.25N 76.34.07E	Bahubali (H×B)	Irrigated	1.98	2.08	27.99	29	25.00	32.26	30.75
	Nandanahalli	14.16.44N 76.35.02E	Bullet (H×H)		2.18		25.91			21	
Davanagere	Hebbalu	14.22.46N 76.05.15E	Yuva (H×B)	Irrigated	2.97	2.95	33.15	37	40.00	36.19	37.32
	Kanivebilachi	14.10.11N 75.50.63E	First class (H×H)		2.93		36.47			43	
Dharwad	Govinakoppa	15.28.02N 75.05.42E	Bunny (H×H)	Rainfed	4.96	5.08	36.47	45	43.00	41.15	42.19
	Byahatti	15.26.38N 75.12.06E	First class (H×H)		5.19		38.64			41	
Gadag	Venkatapura	15.21.01N 75.51.17E	ATM (H×H)	Rainfed	2.06	2.13	29.62	26	28.00	33.04	31.63
	Timmlapura	15.17.42N 75.84.62E	Jadoo (H×H)		2.19		31.34			30	
Haveri	Devihosur	14.48.09N 75.19.28E	Neeraj (H×B)	Rainfed	4.52	4.60	33.05	41	45.00	50.49	51.03
	Kabbur	14.44.24N 75.19.52E	MRC-7351 (H×B)		4.68		43.98			49	
Kalaburgi	Taranahalli	17.12.16N 77.16.28E	RCH-569(H×H)	Irrigated	5.22	5.33	40.76	46	47.50	58.49	59.49
	Hosalli	17.09.58N 77.14.00E	ATM (H×H)		5.43		42.46			49	
Mysuru	Taggluru	11.56.09N 76.40.16E	Minarva (H×B)	Irrigated	4.19	4.20	37.19	45	43.00	43.61	42.75
	Begur	11.55.01N 76.39.55E	Bahubali (H×B)		4.21		36.82			41	
Raichur	Sathyaranyana camp	16.27.36N 77.21.70E	Jadoo (H×H)	Irrigated	5.89	5.97	45.00	62	61.00	61.48	62.69
	Kurdi	16.08.25N 77.20.81E	Jadoo (H×H)		6.04		40.56			60	
Shivamogga	Anvatti	14.55.03N 75.15.30E	Flux (H×H)	Irrigated	2.16	2.07	23.79	13	11.50	29.92	30.21
	Sominakoppa	14.01.03N 75.37.11E	Frist class (H×H)		1.98		25.69			10	
Uttara Kannada	Mundgodu	14.97.36N 75.04.06E	Yuva (H×H)	Rainfed	0.71	0.97	10.92	7	9.00	12.08	12.89
	Nandikatta	15.02.41N 74.59.36E	Super fiber (H×B)		1.23		10.06			11	
Vijayapura	Bibi.Ingalagi	16.38.30N 76.14.30E	Shabari (H×H)	Irrigated	3.16	2.91	31.59	38	38.00	38.94	35.57
	Hanchali	16.39.09N 76.13.36E	Bunny (H×H)		2.65		39.27			38	
Mean					3.51		33.53		36.50		41.30

**Table 3:** Incidence pattern of pink bollworm *Pectinophora gossypiella* Sanders in Karnataka (Pool)

Districts/Villages		Genotypes	Rosetted flowers (%)	Green boll damage (%)	No of larvae/50 bolls	Locule damage (%)				
Bagalakote	Kittli	Jadoo (H×H)	2.83	3.25	32.70	32.87	35.00	34.50	37.55	37.66
	Kelur	Jadoo (H×H)	3.67		33.04		34.00		37.77	
Ballari	Rampura	Bullet (H×H)	5.62	5.68	45.83	45.52	49.50	50.25	57.75	57.34
	Dasapura	Challenge (H×B)	5.74		45.21		51.00		56.93	
Belagavi	Saundatti	Jadoo (H×H)	4.62	4.32	36.43	38.41	41.50	41.50	53.86	53.75
	Vakkunda	Jadoo (H×H)	4.02		40.39		41.50		53.65	
Chitradurga	Kurudihalli	Bahubali (H×B)	2.32	2.26	29.63	29.29	30.50	27.50	34.70	34.62
	Nandanahalli	Bullet (H×H)	2.21		28.94		24.50		34.55	
Davanagere	Hebbalu	Yuva (H×B)	3.94	3.76	35.58	36.67	39.50	39.50	44.43	45.42
	Kanivebilachi	First class (H×H)	3.57		37.75		39.50		46.40	
Dharwad	Govinakoppa	Bunny (H×H)	5.22	5.25	39.81	39.87	47.50	47.00	48.99	50.23
	Byahatti	First class (H×H)	5.28		39.93		46.50		49.94	
Gadag	Venkatapura	ATM (H×H)	3.05	2.96	30.99	31.33	29.50	31.25	35.36	35.30
	Timmlapura	Jadoo (H×H)	2.86		31.68		33.00		35.23	
Haveri	Devihosur	Neeraj (H×B)	5.12	5.26	41.05	44.14	45.50	48.50	54.23	54.93
	Kabbur	MRC-7351 (H×B)	5.41		47.22		51.50		55.63	
Kalaburgi	Taranahalli	RCH-569(H×H)	5.76	5.82	53.21	50.64	48.00	50.25	60.42	62.05

	Hosalli	ATM (H×H)	5.89		48.07		52.50		63.69	
Mysuru	Taggluru	Minarva (H×B)	5.22	5.34	54.11	53.68	50.00	48.50	55.37	55.47
	Beguru	Bahubali (H×B)	5.46		53.25		47.00		55.58	
Raichur	Sathyanarayana camp	Jadoo (H×H)	6.23	6.14	58.63	57.76	62.00	59.75	67.40	67.76
	Kurdi	Jadoo (H×H)	6.04		56.89		57.50		68.13	
Shivamogga	Anvatti	Flux (H×H)	2.16	2.20	26.90	27.86	21.00	20.75	30.49	32.82
	Sominakoppa	Frist class (H×H)	2.25		28.82		20.50		35.16	
Uttara Kannada	Mundgodu	Yuva (H×H)	1.05	1.23	10.92	10.87	8.50	10.50	15.51	16.42
	Nandikatta	Super fiber (H×B)	1.40		10.83		12.50		17.34	
Vijayapura	Bibi.Ingalagi	Shabari (H×H)	3.61	3.62	34.72	36.29	37.00	37.50	41.91	39.52
	Hanchali	Bunny (H×H)	3.64		37.86		38.00		37.13	
Mean			4.08		37.98		39.09		45.95	

**Table 4:** Infestation level of pink bollworm *P.gossypiella*

a) Rosetted flowers (%)	Infestation level	Districts
<10%	Below ETL	Bagalakote, Vijayapura, Kalaburgi, Gadag, Davanagere, Shivamogga, Chitradurga, Dharwad, Belagavi, Mysuru, Ballari, Raichur, Haveri and Uttara Kannada
10-20%	Low	-
20-50%	Moderate	-
>50%	Severe	-
b) Green boll damage (%)	Infestation level	Districts
<10%	Below ETL	-
10-20%	Low	Uttara Kannada
20-50%	Moderate	Bagalakote, Vijayapura, Kalaburgi, Gadag, Davanagere, Shivamogga, Chitradurga, Dharwad, Belagavi, Ballari and Haveri
>50%	Severe	Mysuru and Raichur
c) Locule damage (%)	Infestation level	Districts
<10%	Below ETL	-
10-20%	Low	Uttara Kannada
20-50%	Moderate	Bagalakote, Vijayapura, Kalaburgi, Gadag, Davanagere, Shivamogga and Chitradurga
>50%	Severe	Dharwad, Belagavi, Mysuru, Ballari, Raichur and Haveri

**Table 5:** Influence of irrigation on pink bollworm incidence (Poled across locations and years)

Observations	Irrigated crop	Rainfed crop
Rosetted flowers (%)	4.23	1.46
Green boll damage (%)	40.78	32.96
No of larvae/50 bolls	40.94	35.75
Locule damage (%)	48.07	41.93

**Table 6:** Influence of plant type on pink bollworm incidence (Poled across locations)

Observations	2017-18	
	H×H Hybrids	H×B Hybrids
Rosetted flowers (%)	4.49	5.04
Green boll damage (%)	40.79	46.52
No of larvae/50 bolls	40.75	44.00
Locule damage (%)	49.32	53.29
Observations	2018-19	
	H×H Hybrids	H×B Hybrids
Rosetted flowers (%)	3.47	3.61
Green boll damage (%)	33.86	32.72
No of larvae/50 bolls	35.95	37.88
Locule damage (%)	41.72	40.26
Observations	Pooled	
	H×H Hybrids	H×B Hybrids
Rosetted flowers (%)	3.98	4.33
Green boll damage (%)	37.33	39.61
No of larvae/50 bolls	38.35	40.94
Locule damage (%)	45.54	46.78

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