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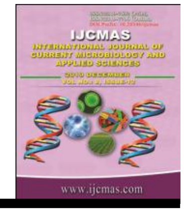

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Seasonal Incidence of Pink Bollworm *Pectinophora gossypiella* (Saunders) on Bt Cotton

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A B S T R A C T

The field experiments were carried out during *Kharif* 2017-18 at Hittinahalli village near the College of Agriculture, Vijayapura. The contemporary research unveiled that peak moth activity was observed during the II week of December (47^{th} standard meteorological week) (52.78 moths / trap / night). Later on, the trap catches declined gradually with a minimum trap catch of 12.50 moths / trap / night. The rosette flowers were ranged from (2.25 to 15.45%) with seasonal mean of (9.05 %). While the incidence in green bolls was noticed from the first fortnight of September (34^{th} SMW) and rose gradually to reach its zenith during the second fortnight of December (48^{th} SMW). The larval incidence ranged from (9.00 to 51.00 larvae/50 bolls) with a mean of (34.75 larvae /50 bolls) and the green boll damage ranged from (7.60 to 42.21 %) with mean of (30.52 %). Moreover, open boll damage was ranged from (48.36 to 53.48 %) with a mean of (53.45 %) during the cropping season. Furthermore, locule damage ranged from (24.71 to 39.35 %) with a mean of (39.05 %). The trap catches had a negative and non-significant relationship with rainfall and a negative and significant relationship with maximum temperature.

Introduction

Cotton (*Gossypium* spp.) is the most prominent mercenary fibre crop of India, producing natural fibre, fuel and edible oil, is playing an important role in Indian economy (Patil, 2003; Prasad *et al.*, 2018). It is a perennial semi-shrub grown as an annual crop in both tropical and warm temperate regions (Rahman *et al.*, 2012; Chakravarthy *et al.*, 2012; Syed *et al.*, 2015) which has been under commercial cultivation for domestic consumption and export needs of 111 countries in the world (Anonymous, 2015; Srinivas, 2018) and hence it is called "King of Fibres" or "White Gold". In addition to textile manufacturing, it provides seeds with a potential multi-product base such as hulls, oil, lint and food for animals (Ozyigit *et al.*, 2007).

Only in India, all the four spinnable fiber yielding species of *Gossypium* viz., *Gossypium hirsutum*, *G. barbadense*, *G. arboreum*, and *G. herbaceum* are cultivated commercially. It provides subsistence for millions of people and is also one of the major foreign earners of the country (Ahmad *et al.*, 2011) contributing up to 75 per cent of total raw material needs of the textile industry and affords employment to about 60 million people (Sandhyarani, 2010; Kranthi, 2011)

India is an important producer of cotton on a global scale. India is the second-largest country to produce cotton after China (Sandhyarani, 2010), it deems for 36 per cent (118.72 lakh hectare) of the world's total area with 25 per cent (352 lakh bales) of seed cotton. The average productivity of cotton in India is 504 kg ha^{-1} which is pretty low as compared to the world average of 786 kg ha^{-1}.

In Karnataka, cotton occupies the area of about 8.75 lakh hectares with a total production of 23.12 lakh bales with the average productivity of 735 kg ha^{-1} (Anonymus, 2016).

The lower productivity of cotton in India corresponded to the world average (786 kg ha^{-1}) is due to the spectrum of insects pests on cotton. Worldwide, about 1326 insect species are enlisted in cotton (Hargreaves, 1948; Atwal, 2004) of which about 162 species of insects infest at various stages of crop growth, of which around 15 are key pests (Kannan *et al.*, 2004).

Among the array of insects, especially the bollworms (Dhurua & Gujar 2011) viz., American bollworm, *Helicoverpa armigera* (Hubner), Spiny bollworm, *Earias insulana* (Boiusduval), Spotted bollworm, *Earias vittella* (Fabricius) and Pink bollworm, *Pectinophora gossypiella (*Saunders) normally referred as bollworm complex, pose greater threat to cotton production (Ghosh, 2001; Kranthi, 2015).

The management of insect pests through synthetic insecticides was practiced and regarded as a boon during the green revolution era. Sole reliance on synthetic insecticides particularly pyrethroids (Ramasubra-manyam, 2004) caused an imbalance in the agro-system creating resistance and resurgence problems warranting alternate control measures (Natwick, 1987; Prasad, 2018) On average, farmers apply six to eight rounds of insecticides in the rainfed situation and 12 to 18 rounds in the irrigated situation (Kulkarni *et al.,* 2003). Out of this, bollworm control alone takes about 80 % of the insecticides worth of around 12 billion rupees and accounting for about one-third of current pesticide sales (Gupta, 2001).

To reduce pesticide usage on cotton, as an alternative approach to manage bollworm, the inserting of a foreign gene through genetic engineering and evolving transgenic cotton considered as an important milestone for the management of major pests particularly bollworms without inimical effects on eco-system (ISAAA, 2016).

Transgenic cotton containing single toxin (*Cry* 1Ac) Bt-1 has been commercialized during 2002 to afford protection against cotton bollworms (Choudhary, 2013) viz., *Helicoverpa armigera*, *H. virescens*, *Earias vittella*, *Earias insulana*, and *Pectinophora gossypiella* in India (Kranthi, 2012).

Further, to enhance the efficacy and durability of the GM technology for bollworm control, second-generation GM-Bt cotton (Bt-II) expressing two Bt proteins, 'Cry1Ac + Cry2Ab,' was introduced into India in 2006

(Choudhary, 2013). PBW populations were reported to have developed resistance to Cry1Ac and were found to survive on Bt-I cotton fields in 2009 in Gujarat State in India, but were being effectively controlled by the dual-gene Bt-II cotton (Dhurua & Gujar 2011). However, Surveys conducted across India showed progressive increases in the survival rate of PBW larvae in green bolls of Bt-II cotton F1 hybrid varieties (Vakudavath, 2018).

In Bt cotton, the expression of cry protein toxin varied throughout the cropping period and declines after 85-100 DAS in the plant system due to abiotic factors (Kranthi *et al.*, 2002) particularly under moisture stress and poor soil nutritional condition (Blaise *et al.*, 2011). Since the pink bollworm is a late-season pest, its appearance coincides with the declination of cry protein. Hence, there is every chance for its survival in Bt cotton and inflict damage to the later formed bolls. In recent years, the incidence of pink bollworm is assuming a major proportion even in Bt cotton hybrids viz., MRCH-7383 and MRCH-7357 BG-II hybrids suspecting that pink bollworm has developed resistance against Bt cotton. With this background, Studies on the population dynamics of pink bollworm on the Bt cotton hybrid was undertaken.

Materials and Methods

Experimental details

Field experiments were conducted at the farmer field in Hittinahalli village, about 3 km away from the College of Agriculture, Vijayapura. The seeds of Bt cotton hybrid MRCH-7383 were sown with a spacing 120 × 90 cm between rows and plants respectively, in an area of about ten gunta. And crop was raised as per recommended agronomical practices and following observation were recorded.

Per cent Rosette flower

The observations on rosette flower due to pink bollworm (PBW) infestation were recorded from 60 DAS in fortnightly intervals on 50 randomly selected plants. Later, the total numbers of flowers and rosette flowers were counted and the per cent rosette flowering was worked out using formula.

$$\text{Rosette flower (\%)} = \frac{\text{Total no. of rosette flowers / plant}}{\text{Total no. of flowers / plants}} \times 100$$

Larval population in green bolls

The observation on the occurrence of PBW in green bolls was recorded at fortnightly intervals. For this purpose, 50 tender green cotton bolls of three-week age was collected and brought to the laboratory for further observations. Each tender green boll was cut opened along with ridges of the locules with the help of sharp cutter to see the presence of larvae. Finally, the total number of pink bollworm larvae per 50 green bolls was worked out using the following formula.

$$\text{Larval population (\%)} = \frac{\text{No. of larvae in green bolls}}{\text{Total no. of green bolls}} \times 100$$

Green boll damage

During larval counts, the number of bolls damaged by pink bollworm was counted and expressed in terms of per cent tender green boll damage using the formula

$$\text{Green boll damage (\%)} = \frac{\text{No. of damaged green bolls}}{\text{Total no. of green bolls}} \times 100$$

Opened boll damage

Before commencement of each picking, the total number of Good opened bolls (GOB) and badly opened boll (BOB) were counted on 50 randomly selected plants and expressed in per cent (%), as below.

$$\text{Open boll damage (\%)} = \frac{\text{Total no. of BOB's / plant}}{\text{Total no. of opened bolls / plant}} \times 100$$

Locule damage

Before the commencement of each picking, 50 bolls were sampled randomly from the field. Then the total number of locules and damaged locules were counted and expressed in terms of per cent locule damage, as below.

$$\text{Locule damage (\%)} = \frac{\text{Total no. of damaged locules}}{\text{Total no. of locule}} \times 100$$

Trap catches

To monitor the moth activity of pink bollworm during the cropping period, two sleeve pheromone traps of pink bollworm *P. gossypiella* (Saunders) were installed in Bt cotton field at farmer field, Hittinahalli. The septa with Pectnio-lure (cis-7 hexadecen-1-ol acetate) were changed at 15 days interval for the pink bollworm. A weekly collection of moths from each trap was made and the total number of moths of pink bollworm was pooled separately for every standard week and the mean number of catches of pink bollworm per standard week was calculated. In order to find out the impact of environmental factors on the trap catches of pink bollworm on *Bt* cotton weather data such as rainfall, maximum temperature, minimum temperature, morning and afternoon relative humidity were collected. Average weekly weather parameters were calculated based on the weather data collected from the RARS, Vijayapura. Trap catches of pink bollworm for each standard week were correlated and regressed for comparison.

Results and Discussion

The pheromone trap catches unveiled that moth trap was increased gradually with the initial peak of 11.07 moths/trap/ week at August IV week (33rd SMW (standard meteorological week) and increased steadily to reach its peak during III weeks of November (44th SMW (59.50 moths / trap / night) and dwindled gradually. Moreover, peak moth activity was observed during the II week of December (47th SMW) (52.78 moths / trap / night). Later on, the trap catches went on settled with minimum trap catch of 12.50 moths / trap / night gradually. Consequently, two major peaks of moth activity were observed during the season (Table 3). These findings are close congruity with (Babu, 2014) who reported the peaks of moth populations of pink bollworm during the 41-52nd SMW compared with the larval population in the field. Similarly (Pazhanisamy, 2011) reported six peak catches of pink bollworm were observed during 45th, 46th, 47th, 48th, 49th and 50th SMW of trap catches 156.9/trap/week, 186.1 trap/week, 390/trap/week, 432.5/trap/week, 306.2/trap /week and 148.5/trap/week, respectively.

The incidence of pink bollworm was recorded on the flowers by counting the total number of rosette flowers on 50 randomly selected plants. The incidence was noticed from the first fortnight of September (34th SMW) and increased gradually with the progression of crop growth reaching its peak incidence during the second fortnight of September (36th SMW) (18.46 %). Hereafter, the incidence of pink bollworm in rosette flowers declined gradually and become negligible with the formation of bolls. The per cent rosette flower was ranged from 2.25 to 18.46 during the cropping period. (Table 1) During peak incidence, the considerably high (18.46 %) of rosette flowers was noticed during the second fortnight of September with a seasonal mean of (9.05 %). Pink bollworm incidence in cotton flowers revealed that even the Bt cotton has a significant incidence of pink bollworm on the cotton flower (Table 1). These results stand in the persuasion of (Patil, 2002) who recorded maximum per cent rosette flowers was 21.12 per cent in 2001-02 to 23.55 per cent during 2004-05 seasons with the highest incidence of bolls to the tune of 38.75 to 54.45 per cent. Likewise, (Verma *et al.,* 2017) recorded 3.33 per cent rosette flower during the month of July 2017.

The incidence of pink bollworm larvae on green bolls of Bt cotton was noticed from second fortnight of September (36th standard week) (9 larvae / 50 bolls) and increased gradually to reach its peak during the second fortnight of December (48th standard week) (51 larvae / 50 bolls). Thereafter, the larval population was declined. However, the population was continued to observe until the crop harvest (Table 1). The probable reasons for the higher incidence of PBW during this period might be due to availability tender green bolls in abundance and favourable weather conditions coincide with the declination of expression of Cry protein at the later stage of the crop which enabled the larval population to survive in the green bolls. Contemporary findings are comparable to (Verma *et al.,* 2017) who recorded the peak larval population on cotton bolls in the 2nd week of September with an intensity of 7.00 larvae / 30 bolls in 2012 and 2013. Peak infestation was recorded in 3rd week of September with the intensity of 8.00 larvae / 30 bolls. Similarly, Patil *et al.,* (2007) recorded the highest larval load of pink bollworm 67.00 and 42.00 larvae per 20 green bolls during 2005-06 and 2006-07, respectively.

The green boll damage due to PBW was noticed from the second fortnight of September (36th standard week) (7.6 %) and went on increasing up to December second fortnight (48th standard week) reaching its peak (42.21 %). Thereafter, the green damage declined with the maturity of bolls. The green boll damage on cotton was ranging from 7.6 to 42.21 per cent per 50 bolls with a seasonal mean of 30.52 per cent during the cropping period. (Table 1) Present results are corroborated to (Kalkal *et al.,* 2014) who reported a maximum infestation of pink bollworm in green cotton bolls on VBCH-1006 Bt being 3.25, 3.75 and 5.00 per cent at 80, 110 and 140 DAS, respectively. Furthermore, (Kranthi, 2015) reported that pink bollworm larval on BG-II was recorded significantly higher during 2012, 2013 and 2014, and the damage ranged between 0-80 per cent on BG-II hybrids. Besides, (Babu *et al.,* 2015) recorded 2.50 to 47.79 and 0.05 to 1.90 per cent infestation of pink bollworm to green bolls in Vadodara and Kheda districts, respectively. In contradiction to these findings, (Badiger *et al.,* 2011) recorded 1.19 larvae per 20 green bolls in MRC-7918 BG-II hybrid.

The opened boll damage recorded due to pink bollworm infestation was ranged from 48.36 and 48.80 per cent from first to fourth picking and reached its peak during second picking of crop with seasonal mean of 66.32 per cent (Table 2). These results stand in line with (Patil *et al.,* 2011) who recorded 22.97 per cent open boll damage during the cropping period.

Similarly, (Verma, 2017) reported that in Kharif 2012 open boll damage was observed to be 28.88 per cent and in Kharif 2013 open boll damage was recorded as 29.99 per cent.

The locule damage due to pink bollworm infestation was varied from 24.71 to 39.35 per cent. The maximum per cent locule damage was recorded during fourth picking with a seasonal mean of 39.35 per cent (Table 2). Alike results were given by (Patil, 2002) who reported the increased locule damage of about 44.80 per cent during 2001-02 to 62.56 per cent during 2004-05 of the cropping season.

Table.1 Incidence of pink bollworm on *Bt* cotton (Vegetative stage)

Fortnight intervals	Rosetted flower (%)	No. of larvae /50 bolls	Green boll damage (%)
September			
I fortnight	15.79	-	-
II fortnight	18.46	9.00	7.60
October			
I fortnight	9.60	22.00	20.50
II fortnight	7.73	29.00	26.31
November			
I fortnight	8.71	40.00	36.40
II fortnight	7.84	42.00	38.41
December			
I fortnight	6.80	43.00	41.30
II fortnight	4.35	51.00	42.21
January			
I fortnight	2.25	42.00	31.50
Mean	**9.05**	**34.75**	**30.52**
SD ±	**5.13**	**13.75**	**11.91**

Table.2 Incidence of pink bollworm on *Bt* cotton (At harvesting stage)

No. of pickings	Open boll damage (%)	Locule damage (%)
1st picking	48.80	24.71
2nd picking	53.48	27.12
3rd picking	48.36	35.42
4th picking	53.26	39.35
Mean	**66.32**	**31.65**
SD ±	**2.77**	**6.88**

Table.3 Average moth trap catch / trap / night of pink bollworm and average weather parameters during (2017-18)

Standard week	No. moths/trap/night (mean of two traps)	Rainfall (mm)	Temperature (^{0}C)		Relative humidity (%)	
			Maximum	Minimum	Morning (RH_1)	Afternoon (RH_2)
AUG IV	11.07	51.30	32.50	21.40	92.70	67.60
SEP I	20.15	24.40	30.90	21.10	91.30	71.10
II	24.43	61.80	29.80	20.40	94.30	70.40
III	30.15	22.60	29.90	20.90	93.70	71.00
IV	31.45	63.20	31.80	21.70	92.60	65.40
OCT I	32.40	47.60	31.80	22.00	93.60	67.90
II	36.12	9.80	29.10	20.60	91.70	69.90
III	35.25	67.20	32.00	20.70	92.60	58.70
IV	41.78	23.00	31.80	21.80	93.70	53.40
NOV I	50.64	116.60	31.00	21.10	96.60	66.90
II	49.00	6.80	31.60	19.80	88.60	48.70
III	59.50	0.00	31.50	19.60	88.40	47.10
IV	50.35	2.40	30.70	15.40	81.70	34.00
DEC I	50.92	0.00	30.60	15.30	81.70	39.10
II	52.78	0.00	30.80	14.60	74.90	37.00
III	47.85	0.00	31.80	18.50	85.00	48.10
VI	39.85	0.00	30.30	12.80	91.30	47.00
JAN I	32.21	18.20	29.50	17.60	87.40	50.40
II	32.78	0.00	30.60	14.10	89.70	41.90
III	21.28	0.00	28.70	10.10	83.70	39.30
VI	26.14	0.00	29.10	9.40	83.10	36.90
FEB I	14.00	0.00	30.30	10.90	67.00	27.30
II	12.50	0.00	30.30	10.10	65.30	26.50

Table.4 Correlation between pink bollworm trap catches and weather parameters

Pink bollworm	Temperature (^{0}C)		Relative humidity (%)		Rainfall (mm)
	Maximum	Minimum	Morning (RH_1)	Afternoon (RH_2)	
P. gossypiella	-0.59*	0.18	0.08	0.01	-0.42*

*Significant (N = 20, *P* = 0.05)

Table.5 Multiple regression equation between pink bollworm trap catches and weather parameters

Pink bollworm	Regression Equation	R^2
P. gossypiella	$Y= 5.18 - 0.64x_1 + 0.33x_2 + 0.06x_3 + 0.12x_4 – 0.05x_5$	0.68

Relationship between pink bollworm trap catches and weather parameters

To understand the relationship between the activity of moths and the prevailing weather parameters, the data of trap catches and weekly weather parameters (Table 4) subjected to correlation analysis. The pink bollworm trap catches had a negative and non-significant relationship with rainfall (r = -0.42), and a negative and significant relationship with maximum temperature (r = -0.59). Whereas, minimum temperature (r = 0.18), morning relative humidity (r = 0.08) and afternoon relative humidity (r = 0.01), are positive and non-significantly correlated (Table 4).

After regressing, the pink bollworm trap catches data with weather parameters, the following multiple regression equation was obtained (Table 5).

$$Y= 5.18 - 0.64x1 - 0.33x2 + 0.06x3 + 0.12x4 - 0.05x5$$

Where,

Y = Pink bollworm trap catches
X1 = Maximum temperature (^{0}C)
X2 = Minimum temperature (^{0}C)
X3= Morning relative humidity (%)
X4 = Afternoon relative humidity (%)
X5 = Rainfall (mm)

The multiple regression equation indicated that, for every unit increase in minimum temperature, morning relative humidity and afternoon relative humidity increase the PBW trap catches by 0.33, 0.06 and 0.12 units, respectively. Whereas, every unit increase in maximum temperature and rainfall decreases the PBW trap catches by 0.64 and 0.05 units, respectively. The weather parameters influenced the PBW trap catches to the extent of 68 percent (R^2 = 0.68).

Owing to the aforementioned results, conclusions can be made about a given species. In their turn, conclusions often lead to decision-making about, for instance, controlling or protective measures. In particular, in pest management, the information gained about pest incidence in a given field or area is then used to make a decision about pesticide application. To avoid unjustified decisions and unnecessary losses, the quality of the information about the seasonal incidence is therefore a matter of primary importance.

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References

Ahmad, N., Khan, M.H., Khan, G. Z. and Tofique, M., 2011, Provision of supplemental food for the conservation of beneficial insects in cotton field. *Pak. J. Entomol.* Karachi 26(2): pp 95-100.

Anonymous, 2016, *Annu. Rep. Dept. Ent.*, BACA, Anand Agriculture University, Anand, pp. 33- 34.

Anonymous, 2015, Area, production and productivity of cotton in India: State wise production of cotton. Cotton Advisory Board, Mumbai. (Fide: www.cotcorp.gov.in).

Atwal, A. S., 2004, *Agricultural pests of south Asia and their management*. Ludhiana, Kalyani Publishers, New Delhi, India. pp. 221.

Babu, R. S. and Meghwal, M. L., 2014, Population dynamics and monitoring of sucking pests and bollworms on *Bt* cotton in humid zone of Southern Rajasthan. *The Bioscan, Int. Quart J. Life. Sci.*, 9(2): 629-632.

Badiger, H. K., Patil, S. B., Udikeri, S. S., Biradar, D. P., Chattannavar, S. N., Mallapur, C. P. and Patil, B. R., 2011, Comparative efficacy of inter-specific cotton hybrids containing single and stacked *Bt* genes against pink bollworm, *P. gossypiella* (Saund.) and tobacco caterpillar, *S. litura* (Fab.). *Karnataka J. Agri. Sci.*, 24(3): 320-324.

Blaise, D. and Kranthi, K. R., 2011, Cry1Ac expression in transgenic *Bt* cotton hybrids is influenced by soil moisture and depth. *Curr. Sci.*, 101(6): 783-786.

Chakravarthy, V. S., Reddy, T. P., Reddy, V. D., Rao, K. V., 2012, Current status of genetic engineering in cotton (*Gossypium hirsutum* L): an assessment. *Crit Rev Biotechnol*. 34:144–160.

Choudhary, B. and Gaur K., 2013, *Bt Cotton in India: A Country Profile*. *ISAAA Series of Biotech Crop Profiles*. ISAAA, Ithaca, NY.

Dhurua, S. and Gujar, G. T., 2011, Field-evolved resistance to *Bt* toxin Cry1Ac in the pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae), from India. *Pest Manag Sci* 67:898–903.

Ghosh, P. K., 2001, ISCI Silver Jubilee Lecture Series-Lecture on “Genetically modified crops in India with special references to *Bt*-cotton”. *J. Indian Soc. Cott. Improv*., 18(4): 106-107.

Gupta, G, P., 2001, Role of neem in sustainable cotton pest management, *Natn. J. Plant. Improv*., 30(4): 37-43.

Hargreaves, H., 1948, List of recorded cotton insects of the world. Common Wealth Institute of Entomology, London, p.50.

ISAAA, 2016, *Global Status of Commercialized Biotech/GM Crops: ISAAA Brief* No. 52. ISAAA, Ithaca, NY (2016).

Kalkal, D., Roshan, L., Dahiya, K. K., Jat, B. L. and Ankit, K., 2014, Effect of abiotic factors on population dynamics of pink bollworm in relation to genetically modified cotton. *J. Cotton. Res. Dev.*, 28(2): 280-285.

Kannan, M., Utamasamy, S. and Mohan, S., 2004, Impact of insecticides on sucking pests and natural enemy complex of transgenic cotton. *Curr. Sci*., 86(4): 726-729.

Kranthi, K. R., Jadhav, D. R., Kranthi, S., Wanjari, R. R., Ali, S., Russell, D., 2002, Insecticide resistance in five major insect pests of cotton in India. Crop Prot. 21:449–460.

Kranthi, K. R., 2015, Pink bollworm strikes *Bt* cotton. *Cotton Statistics News*, 35(1): 1-6.

Kulkarni, K. A., Patil, S. B and Udikeri, S. S., 2003, Sustainable insect pest management. In: “*Nat. Symp. Sustain. Insect Pest Manag.*” Chennai. February, 6-7. 2003, pp. 232-240.

Natwick, E.T., 1987, Cotton insects and production, Colorado River Cotton Growers Association, El Centro, CA, 1987, 3-4.

Ozyigit, I. I., Khaharaman, M. V. and Ercan, O., 2007, Relation between explants age, total phenols and regeneration response in tissue cultured cotton (*Gossypium hirsutum* L.). *Afric. J. Biotech*., 6(1):003-008

Patil, B. V., Bheemanna, M., Hanchinal, A. C., Hosmani, A. C. and Bansi, A. B., 2007, Studies of pink bollworm, *Pectinophora gossypiella* (Saunders) on cotton at Raichur, *Karnataka J. Cotton Res. Dev.*, 21(2): 224-226.

Patil, S. B., 2002, Studies on management of cotton pink bollworm *Pectionophora gossypiella* (Saunders) (Lepidoptera: Gelechidae). *Ph.D. Thesis*, Uni. Agric. Sci., Dharwad (India), pp. 43-61.

Patil, S. B., 2011, Strategies for the management of cotton pink bollworm by supervisory control of pink bollworm in cotton. *Ph.D. Thesis*, Uni. Agric. Sci., Dharwad (India). pp. 46-65.

Patil, S.B., 2003, Studies on Management of Cotton Pink Bollworm Pectionophora Gossypiella (Saunders) (Lepidoptera: Gelechiidae). Ph. D. Thesis submitted to University of Agricultural Sciences, Dharwad (India).

Pazhanisamy, M and Deshmukh, S.D., 2011, Influencing of weather parameters on pheromone trap catches of cotton bollworms, Recent Research in Science and Technology 2011, 3(4): 136-139.

Prasad, B. R., Rahman, S. J., Sudarshanam, A and Raghu P. R. R.., 2018, Assessment of different modules for management of pink bollworm, *Pectinophora gossypiella* (Saunders) in *Bt* cotton. *J. Entomo and Zoo Studies* 2018; 6(6): 132-135.

Rahman M, Shaheen T, Tabbasam N, Iqbal MA, Ashraf M, Zafar Y, Paterson AH. 2012. Cotton genetic resources: a review. Agron Sustain Dev. 32:419–432.

Ramasubramanyam, T., 2004, Magnitude, mechanism and management of pyrethroids resistance in *Helicoverpa armigera* (Hubner) in India. J. Entomol. 1, 6–11.

Sandhya Rani, B., Prasad, N.V.V.S.D., Arjuna Rao, P., Srinivasa Rao, V., 2010, Seasonal progression and incidence of *Pectinophora gossypiella* (Saunders) on Cotton, *Ann. PI. Protec. Sci.*, 18(2): 323-326.

Shrinivas, Sreenivas, A. G., Hanchinal, S. G., Hurali, S. and Beldhadi, R. V., 2018, Comparative biology of pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) on different hosts. *J. Ento and Zoo Studies*, 2019; 7(1): 1053-1060.

Syed, A. H., Muhammad, N. I., Saleem, J., Shahid, H., 2015, Efficacy of some selected synthetic chemical insecticides and bio-pesticides against cotton mealybug, *Phenacoccus solenopsis* Tinsley (Sternorrhyncha: Pseudococcidae) under agro ecological conditions of Peshawar, Pakistan. *J. Ento and Zoo Studies.*, 2015; 3(6): 223-226.

Vakudavath, C. B. N., Kumbhare, S., Kranthi, S., Satija, U. and Kranthi, K. R., 2018, Field-evolved resistance of pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae), to transgenic *Bacillus thuringiensis* (*Bt*) cotton expressing crystal 1Ac (Cry1Ac) and Cry2Ab in India, *Pest Manag Sci* 2018; 74: 2544–2554.

Verma, S. K., Singh, D. R., Jeewesh, S., Saurabh, S. and Nirvesh Yadav., 2017, Population dynamics of pink bollworm, *P. gossypiella* (Saunders) in cotton crop. *Int. J. Pure Appl. Biosci.*, 5(2): 801-806.

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