Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2020; 8(1): 1131-1135

Received: 19-11-2019
Accepted: 21-12-2019

DU Gosavi
Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

BV Bhede
Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

AG Badgujar
Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

RB Ambad
Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Corresponding Author:
DU Gosavi
Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, Maharashtra, India

Evaluation of proper crop stage and insecticide for management of pink bollworm *Pectinophora gossypiella* Saunders on cotton

DU Gosavi, BV Bhede, AG Badgujar and RB Ambad

Abstract
The field experiment was conducted in *Kharif* season of 2018-19 at Department of Agricultural Entomology, V.N.M.K.V. Parbhani (M.S.), India to evaluate proper crop stage and insecticide for management of pink bollworm on cotton. The experiment was laid out using spilt plot design with 3 replications. The main plots were crop stages *viz.* Square formation (A_1), Flower formation (A_2) Boll formation (A_3) and Boll development (A_4) whereas, sub plots were insecticides *viz*. Azadirachtin 3000 ppm (B_1), Profenophos 50 EC (B_2), Lambda-cyhalothrin 5 EC (B_3), Chlorantraniliprole 18.5 SC (B_4), Profenofos 40 + Cypermethrin 4 EC (B_5). The data on rosette flowers, green boll damage, open boll damage, locule damage and seed cotton yield revealed that the most effective insecticide against pink bollworm was lambda-cyhalothrin 5 EC and followed by profenofos 40 + cypermethrin 4 EC, profenofos 50 EC and chlorantraniliprole 18.5 SC. The proper crop stage for spraying was boll formation followed by flower formation, square formation and boll development stage.

Keywords: Pink bollworm (*Pectinophora gossypiella*), crop stage, insecticides

Introduction
Planting of genetically modified cotton that produce insecticidal proteins derived from the bacterium *Bacillus thuringiensis* (Bt) continues to increase rapidly. The evolution of resistance by insect pests threatens the continued success of this technology. The pink bollworm *Pectinophora gossypiella* (Saund.) (Lepidoptera: Gelechiidae) is one of the most important pests of cotton and is distributed throughout the world's cotton-growing areas (Pearson, 1958) [5]. Pink bollworm has developed resistance to Cry1Ac and Cry2Ab (or Bollgard-II)- the two biotech solutions currently available in India to tackle pink bollworm. Virulent attack of the pest is destroying the fibre crop on lakhs of acres across the country, particularly in the West, Central and Southern parts (Dhurua and Gujar, 2011; Vakudavath, 2018) [1, 6]. Pink bollworm lays eggs on squares, flowers or green bolls. Its destructive larval stage is usually buried within the cotton's fruiting bodies, unreachable by insecticidal sprays. Larvae feed on squares, flowers and bolls, including the seeds within bolls. Larvae immediately begin to bore into squares or bolls after hatching. Hence it is necessary to apply insecticide sprays at proper time. Considering these points, the present investigations were carried out to evaluate proper crop stage and insecticide for management of pink bollworm on cotton.

Materials and Methods
An experiment was conducted at Department of Agricultural Entomology, College of Agriculture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S., India) during *Kharif* 2018-19. Sowing of Bt cotton was done at spacing 120 cm x 45 cm. The experiment was laid out using spilt plot design with 3 replications. The main plots were crop stages *viz.* Square formation (A_1), Flower formation (A_2) Boll formation (A_3) and Boll development (A_4) whereas, sub plots were insecticides *viz.* Azadirachtin 3000 ppm (B_1), Profenophos 50 EC (B_2), Lambda-cyhalothrin 5 EC (B_3), Chlorantraniliprole 18.5 SC (B_4), Profenofos 40 + Cypermethrin 4 EC (B_5). Two sprayings were given of each insecticide. The first spraying was giventhe particular crop stage *i.e.*Square formation (A_1),Flower formation (A_2), Boll formation (A_3) and Boll development (A_4) and the second spraying after 30 days of first spraying.
The observations on rosette flowers (75 and 90 DAS), green boll damage (90, 105, 120, 135 and 150 DAS), open boll damage (120 and 150 DAS), locule damage (after harvesting) and

yield were recorded. The percentage damage was subjected to angular transformations. The transformed data was subjected to ANOVA using OPSTAT software package and result were interpreted.

Results and Discussion

The data on the effect of different insecticides at different crop stage on incidence of pink bollworm and seed cotton yield are presented in Table 1.

Table 1: Effect of different insecticides at different crop stages on incidence of pink bollworm and yield of *Bt* cotton

Treatment	Rosette flowers (%)		Green boll damage (%)					Open boll damage (%)		Locule damage (%)	Yield q/ha		
	75 DAS	90 DAS	90 DAS	105 DAS	120 DAS	135 DAS	150 DAS	120 DAS	150 DAS		Ist picking	IInd picking	Total
A1B1	0.00 (0.00)*	9.81 (18.20)	1.67 (4.30)	21.67 (27.51)	45.00 (42.10)	76.67 (61.20)	96.00 (78.43)	18.97 (25.52)	74.14 (59.70)	35.22 (36.36)	4.13	3.33	7.46
A1B2	0.00 (0.00)	3.37 (10.44)	0.00 (0.00)	16.67 (23.84)	25.00 (29.91)	56.67 (48.85)	83.33 (66.12)	12.22 (20.31)	54.65 (47.66)	25.08 (30.03)	4.87	3.95	8.82
A1B3	0.00 (0.00)	3.10 (9.97)	0.00 (0.00)	3.33 (8.61)	15.00 (22.59)	45.00 (42.10)	76.67 (61.21)	2.26 (7.07)	42.73 (40.79)	20.19 (26.65)	5.80	4.13	9.93
A1B4	0.00 (0.00)	3.67 (10.99)	0.00 (0.00)	15.00 (22.59)	26.67 (30.28)	60.00 (51.12)	85.00 (67.38)	11.67 (19.76)	57.54 (49.32)	29.62 (32.92)	4.81	3.82	8.63
A1B5	0.00 (0.00)	4.85 (12.71)	0.00 (0.00)	13.33 (20.74)	18.33 (24.80)	48.67 (44.22)	80.00 (63.90)	8.47 (16.91)	44.21 (41.66)	21.59 (27.54)	5.18	4.19	9.38
A2B1	2.95 (9.88)	16.67 (24.09)	8.33 (16.20)	15.00 (21.86)	35.00 (36.22)	70.00 (56.98)	95.67 (78.03)	13.69 (21.70)	70.70 (57.26)	33.60 (35.40)	4.75	3.45	8.20
A2B2	1.73 (7.55)	7.78 (16.17)	3.33 (8.61)	6.67 (14.75)	20.33 (26.68)	51.33 (45.74)	76.67 (61.15)	7.28 (14.87)	44.46 (41.78)	20.40 (26.81)	5.30	4.13	9.44
A2B3	0.67 (3.82)	6.69 (14.98)	0.00 (0.00)	3.33 (8.61)	16.67 (23.35)	41.33 (39.95)	68.67 (55.96)	2.89 (9.78)	27.76 (37.33)	17.50 (23.90)	5.80	4.44	10.24
A2B4	1.81 (7.72)	8.01 (16.43)	5.00 (10.45)	8.33 (16.59)	25.00 (29.79)	53.33 (46.93)	78.67 (62.49)	10.35 (18.66)	47.95 (43.81)	24.25 (29.43)	5.06	4.13	9.19
A2B5	1.00 (5.74)	8.33 (16.72)	0.00 (0.00)	5.00 (12.92)	18.33 (24.37)	45.00 (42.07)	73.33 (58.91)	7.52 (15.86)	36.90 (37.37)	20.29 (26.74)	5.30	4.38	9.68
A3B1	5.85 (13.97)	12.04 (20.11)	6.67 (14.75)	13.33 (21.33)	23.33 (28.22)	53.33 (46.90)	71.33 (57.61)	10.28 (18.52)	51.67 (45.94)	25.14 (30.05)	5.00	3.64	8.64
A3B2	4.17 (11.75)	5.03 (12.95)	3.33 (8.61)	6.67 (14.75)	11.67 (19.88)	31.33 (34.02)	63.33 (52.78)	6.39 (14.54)	33.43 (35.24)	16.29 (23.80)	5.43	4.01	9.44
A3B3	7.51 (15.89)	4.77 (12.61)	0.00 (0.00)	3.33 (8.61)	6.67 (14.75)	26.67 (30.98)	56.67 (48.83)	1.75 (4.42)	27.79 (31.58)	13.69 (21.69)	6.04	5.55	11.60
A3B4	6.08 (14.21)	5.10 (13.03)	3.33 (8.61)	6.67 (14.75)	15.00 (22.59)	33.33 (35.15)	68.33 (55.75)	6.78 (14.95)	37.73 (37.89)	18.75 (25.65)	5.37	4.56	9.93
A3B5	3.34 (10.52)	4.85 (12.71)	0.00 (0.00)	3.33 (8.61)	11.67 (19.30)	30.00 (33.16)	58.67 (49.98)	2.12 (6.84)	33.58 (35.34)	16.25 (23.75)	5.92	5.10	11.02
A4B1	6.46 (14.70)	25.00 (29.99)	13.33 (21.33)	26.67 (31.06)	41.67 (40.18)	63.33 (52.73)	81.33 (64.43)	30.35 (32.95)	65.86 (54.41)	31.71 (34.24)	3.02	3.64	6.66
A4B2	5.43 (13.41)	24.44 (29.45)	15.00 (22.59)	21.67 (27.20)	33.33 (35.20)	43.33 (41.14)	70.00 (56.82)	18.59 (24.94)	35.45 (36.49)	17.54 (24.72)	4.19	4.56	8.76
A4B3	3.58 (10.90)	23.33 (28.84)	15.00 (22.77)	15.00 (22.08)	20.00 (26.44)	35.00 (36.26)	61.33 (51.54)	5.75 (13.62)	32.27 (34.45)	15.66 (23.19)	5.49	4.69	10.18
A4B4	4.35 (12.04)	21.67 (27.70)	13.33 (21.33)	20.00 (26.13)	31.67 (34.23)	45.00 (42.10)	71.33 (57.65)	18.16 (25.09)	37.10 (37.49)	18.15 (25.18)	4.13	4.50	8.64
A4B5	4.14 (11.73)	28.89 (32.35)	13.33 (21.33)	15.00 (22.59)	21.67 (27.51)	38.67 (38.43)	65.00 (53.74)	5.90 (13.68)	43.21 (41.03)	16.13 (23.66)	5.49	4.63	10.11
Main (Crop stage)													
A_1	0.00 (0.00)	3.99 (12.46)	0.33 (0.86)	14.00 (20.66)	26.00 (29.94)	57.40 (49.50)	83.80 (67.41)	10.72 (17.92)	54.65 (47.82)	26.34 (30.70)	4.96	3.89	8.84
A_2	1.63 (6.74)	9.49 (17.68)	3.33 (7.05)	7.67 (14.95)	23.07 (28.08)	52.20 (46.33)	78.60 (63.31)	8.35 (16.17)	45.55 (42.39)	23.21 (28.46)	5.24	4.11	9.35
A_3	5.39 (13.27)	6.36 (14.28)	2.67 (6.39)	6.67 (13.61)	13.67 (25.02)	34.93 (36.05)	63.67 (52.99)	5.47 (11.85)	36.84 (37.20)	18.02 (24.99)	5.55	4.57	10.12
A_4	4.79 (12.56)	24.67 (29.67)	14.00 (21.87)	19.67 (25.80)	29.67 (32.71)	45.07 (42.13)	69.80 (56.84)	15.75 (22.05)	42.78 (40.77)	19.84 (26.20)	4.46	4.40	8.87
SE ±	0.30	0.64	1.04	1.51	1.25	1.47	0.80	0.96	0.75	0.83	0.14	0.13	0.20
CD at 5%	1.05	2.25	3.68	5.34	4.42	5.20	2.83	3.37	2.65	2.91	0.48	0.45	0.70
Sub (Insecticide)													
B_1	3.81 (9.63)	15.88 (23.90)	7.50 (14.15)	19.17 (25.45)	36.25 (36.68)	65.83 (54.45)	85.58 (69.63)	18.32 (24.67)	65.59 (54.33)	31.42 (34.01)	4.22	3.51	7.74
B_2	2.83 (8.18)	10.15 (17.25)	5.42 (9.95)	12.92 (20.14)	22.58 (27.92)	45.67 (42.44)	73.33 (59.22)	11.12 (18.67)	42.00 (40.29)	19.83 (26.34)	4.95	4.16	9.11
B_3	2.94 (7.65)	9.47 (16.60)	3.75 (5.69)	6.25 (11.96)	14.58 (21.78)	37.00 (37.32)	65.83 (54.39)	3.16 (8.72)	32.63 (34.64)	16.76 (23.86)	5.78	4.70	10.49
B_4	3.06 (8.49)	9.61 (17.04)	5.42 (10.10)	12.50 (20.02)	24.58 (29.22)	47.92 (43.83)	75.83 (60.82)	11.74 (19.62)	45.08 (42.12)	22.69 (28.29)	4.84	4.26	9.10

B_5	2.12 (6.99)	11.73 (18.62)	3.33 (5.33)	9.17 (16.22)	17.50 (24.00)	40.58 (39.47)	69.25 (56.63)	6.00 (13.32)	39.47 (38.84)	18.56 (25.42)	5.47	4.57	10.05
SE ±	0.28	0.62	1.32	1.34	1.66	1.27	0.97	1.25	1.08	0.68	0.09	0.17	0.20
CD at 5%	0.83	1.79	3.83	3.88	4.48	3.67	2.80	3.61	3.13	1.96	0.27	0.51	0.58
Interaction (Main X Sub)													
SE ±	0.59	1.28	2.59	2.84	3.22	2.70	1.91	2.43	1.68	1.47	0.22	0.34	0.41
CD at 5%	1.81	3.90	NS	NS	NS	NS	NS	NS	NS	NS	0.68	NS	NS

Figures in parentheses are Angular transformed values.

Rosette flowers

75 days after sowing: At 75 days after sowing, the first spraying of insecticides was applied in the plots of square formation (A_1) and flower formation (A_2). The results indicated that the significant differences were noticed among different crop stages. The plots treated with insecticides at square formation recorded nil rosette flowers. The next significantly minimum population was noticed in plots treated at flower formation stage (1.63 per cent). Boll formation and boll development stages were at par with each other as these were not treated with any insecticides up to 75 DAS.

At 75 days after sowing, profenofos 40 + cypermethrin 4 EC (2.12 per cent) recorded significantly lowest rosette flowers among all insecticides except lambda-cyhalothrin 5EC (2.94 per cent). These were followed by profenofos 50EC and chlorantraniliprole 18.5SC. The highest rosette flowers were noticed in the plots treated with Azadirachtin 3000 ppm (3.81 per cent).

The interaction showed that profenofos 40 + cypermethrin 4 EC spraying at square formation was significantly superior.

90 Days after sowing: Up to 90 days after sowing, the plots at square formation (A_1) applied second spraying and the plots at boll formation stage (A_3) sprayed first time with different insecticides. The plots treated at square formation recorded lowest rosette flowers (6.36 per cent) which was at par with plots treated at boll formation stage (8.52 per cent). These were followed by plots treated at flower formation. The remaining plots recorded significantly highest (24.67 per cent) rosette flowers as these were untreated because these should be sprayed at boll development stage.

Among insecticides, lambda-cyhalothrin 5 EC recorded minimum rosette flowers (9.47 per cent) which were at par with chlorantraniliprole 18.5 SC (9.61 per cent) and profenofos 50 EC (10.15 per cent). These were followed by profenofos 40 + cypermethrin 4 EC. The rosette flowers were significantly highest in Azadirachtin 3000 ppm treated plots.

The interaction effect at 90 DAS indicated that lambda-cyhalothrin treated plots at square formation (3.10 per cent) and boll formation stage (4.77 per cent) were significantly superior recording minimum rosette flowers.

Green boll damage

To record green boll damage, 20 green bolls were randomly collected from each plot. These bolls were dissected and recorded healthy and damaged bolls.

90 Days after sowing: Up to 90 DAS, two sprayings were given in plots at square formation (A_1), one spraying in plots at flower formation (A_2) and boll formation stage (A_3). As bolls were not developed at this stage, the plots at boll development stage (A_4) were unsprayed.

The results indicated that the plots sprayed at square formation recorded significantly lowest green boll damage (0.86 per cent). It was followed by boll formation (2.67 per cent) and flower formation stage (3.33 per cent) which were at par with each other. The unsprayed plots which were to be sprayed at boll development recorded significantly highest green boll damage (14.00 per cent).

At 90 DAS, the lowest green boll damage was recorded in the plots treated with profenofos 40 + cypermethrin 4 EC (3.33 per cent) which was at par with lambda-cyhalothrin (3.75 per cent) and profenofos 50 EC (5.42 per cent). These were followed by chlorantraniliprole 18.5 SC (5.42 per cent). The green boll damage was significantly highest in Azadirachtin 3000 ppm (7.50 per cent).

105 days after sowing: Up to 105, DAS the plots of A_1 (square formation) and A_2 (flower formation) received two sprayings. Whereas, the plots of A_3 (boll formation) and A_4 (boll development) received one spraying. There was significant difference between different crop stages and insecticides. But the interaction was non-significant. The plots sprayed at boll formation (A_3) recorded lowest green boll damage which was at par with at flower formation (A_2). In plots treated at boll development (A_4) the green boll damage was highest. However, it was at par with square formation stage (A_1).

At 105 DAS, the treatment Azadirachtin 3000 ppm noticed significantly highest green boll damage (19.17 per cent) than any other insecticides. The green boll damage was significantly lowest in the plots sprayed with lambda-cyhalothrin 5 EC (6.25 per cent). The next effective insecticide was profenofos 40 + cypermethrin 4 EC (9.17 per cent) which was at par with chlorantraniliprole 18.5 SC (12.50 per cent). These were followed by profenofos 50 EC (12.92 per cent).

120 Days after sowing: The data indicated that the green boll damage in different insecticides at different crop stages was significant. The interaction was non-significant. Up to 120 DAS, the plots of A_1 (square formation stage), A_2 (flower formation stage) and A_3 (boll formation stage) received two sprayings of insecticides. Whereas the plots of A_4 (boll development stage) received one spraying.

Among the different crop stages, the green boll damage was significantly minimum in the plots treated at (A_1) square formation stage (13.67 per cent). It was followed by (A_2) flower formation stage (23.07 per cent) and (A_3) boll formation stage (26.00 per cent). The maximum green boll damage was noticed at (A_4) boll development stage (29.67 per cent).

At 120 DAS, significantly lowest green boll damage recorded in the plots treated with lambda-cyhalothrin 5 EC (14.58 per cent) which was at par with profenofos 40 + cypermethrin 4 EC (17.50 per cent). The next best insecticides were profenofos 50 EC (22.58 per cent) and chlorantraniliprole 18.05 SC (24.58 per cent). The treatment Azadirachtin 3000 ppm recorded significantly highest green boll damage (36.25 per cent).

135 Days after sowing: Up to 135 days after sowing, all plots were applied two spraying of insecticides at different crop stages. The results revealed that different crop stages and different insecticides showed significant variation in green boll damage. However, interaction effect was non-significant.
At 135 DAS, the green boll damage ranged from 34.93 to 57.40 per cent. The highest green boll damage was observed in plots sprayed at A_1 (square formation stage) which was at par with A_2 (flower formation stage). The next effective treatment was boll formation and followed by boll development.
The green boll damage at 135 DAS due to spraying of different insecticides ranged from 37.00 to 65.83 percent. Lambda-cyhalothrin 5 EC showed minimum green boll damage which was at par with profenofos 40 + cypermethrin 4 EC. These were followed by profenofos 50 EC and chlorantraniliprole 18.5 SC which were at par with each other. The plots sprayed with NSE registered significantly highest green boll damage. The result at 135 DAS indicated that the green boll damage was lowest when lambda-cyhalothrin 5 EC sprayed at A_3 (Boll formation stage), While the highest when Azadirachtin 3000 ppm sprayed at A_1 (square formation stage).

150 Days after sowing: At 150 DAS, the green boll damage drastically increased. It was ranged from 63.67 to 83.80 percent in different crop stages and from 65.83 to 85.58 percent in different insecticides. The green boll damage was significantly lowest when insecticides applied at boll formation stage (63.67 per cent). It was followed by A_4 (boll development stage) and A_2 (flower formation stage). The highest green boll damage noticed when insecticides sprayed at square formation stage.
At 150 DAS, the plants treated with lambda-cyhalothrin 5 EC (65.83 per cent) recorded significantly lowest green boll damage than other insecticides except profenofos 40 + cypermethrin 4 EC (69.25 per cent). These were followed by profenofos 50 EC and chlorantraniliprole 18.5 SC which were at par with each other. The green boll damage was significantly highest in plots treated with Azadirachtin 3000 ppm (85.58 per cent).
The interaction was non-significant. However, the lowest green boll damage was noticed when lambda-cyhalothrin 5 EC was applied at boll formation (A_3) stage.

Open boll damage
Based on number of bad opened bolls, the per cent open boll damage was calculated. At the time of each picking, total number of good open bolls and bad open bolls were counted on five randomly selected plants.

120 Days after sowing: The result showed significant differences at various crop stages and in various insecticides. However, the differences were non-significant in interaction.
The open boll damage was significantly lowest when sprayed at (A3) boll formation stage (5.47 per cent). The next best stages were (A2) flower formation stage (8.35 per cent) and (A1) square formation stage (10.72 per cent) which were at par with each other. The open boll damage was significantly highest when spraying was taken at boll development (15.75 per cent).
Among the insecticides, Azadirachtin 3000 ppm was less effective recording significantly highest open boll damage (18.32 per cent). The most effective insecticide was lambda-cyhalothrin 5EC which recorded significantly lowest damage (3.16 per cent). The next effective insecticides were profenofos 40 + cypermethrin 4 EC (6.00 per cent), profenofos 50 EC (11.12 per cent) and chlorantraniliprole 18.5 SC (11.74 per cent).
At 120 DAS, the results indicated that the lowest open boll damage was registered when lambda-cyhalothrin 5 EC sprayed at (A3) boll formation stage.

150 Days after sowing: The observations presented on open boll damage at 150 DAS due to spraying of different insecticides at different stages revealed that the significant differences were noticed at crop stages as well as in different insecticides. However, the interaction was not significant. The open boll damage was more as compared to 120 DAS.
Among the crop stages, spraying of insecticides at boll formation stage (A_3) was most effective which recorded significantly lowest open boll damage (36.84 per cent). It was followed by boll development stage (A_4) and flower formation stage (A_2) which were at par with each other. The open boll damage was significantly maximum when sprayed at square formation stage (A_1).
At 150 DAS, the plots treated with Azadirachtin 3000 ppm recorded significantly highest open boll damage. The plots sprayed with lambda-cyhalothrin 5 EC showed lowest open boll damage. It was followed by profenofos 40 + cypermethrin 4 EC, profenofos 50 EC and chlorantraniliprole 18.5 SC.
The data indicated that when crop was sprayed at flower formation stage (A_2) and boll formation stage (A3) with lambda-cyhalothrin5 EC was most effective as the open boll damage was minimum than any other treatment combinations.

Locule damage
The locule damage varied from 18.02 to 26.34 per cent at different crop stages. The lowest locule damage was observed when sprayed at boll formation stage (18.02 per cent) which was at par with boll development stage (19.84 per cent). These were followed by flower formation stage (23.21 per cent) and square formation stage (26.34 per cent) which were at par with each other.
Among the insecticides, the highest locule damage was noticed in Azadirachtin 3000 ppm (31.42 per cent). The locule damage was lowest in lambda-cyhalothrin 5 EC (16.76 per cent) which was at par with profenofos 40 + cypermethrin 4 EC (18.56 per cent). The next effective insecticides were profenofos 50 EC and chlorantraniliprole 18.5 SC which were at par with each other.
The interaction was non-significant. However, when lambda-cyhalothrin 5 EC was sprayed at boll formation stage (A_3), the locule damage was lowest.

Seed cotton yield
First picking: The results indicated that there were significant differences in various crop stages and various insecticides. The interaction effect was also significant.
At first picking, the highest seed cotton yield was recorded when spraying was done at (A_3) boll formation stage (5.55q/ha). However, it was at par with (A_2) flower formation stage (5.24 q/ha) and (A_1) square formation stage (4.96 q/ha). The lowest yield was noticed when insecticides were applied at (A_4) boll development stage (4.46 q/ha).
Among the insecticides, the seed cotton yield was highest in the plots treated with lambda-cyhalothrin 5 EC (5.78 q/ha)

which was at par with profenofos 40 + cypermethrin 4 EC (5.47 q/ha). These were followed by profenofos 50 EC (4.95 q/ha) and chlorantraniliprole 18.5 SC (4.84 q/ha). The seed cotton yield was significantly lowest in Azadirachtin 3000 ppm treated plots (4.22 q/ha).

The result revealed that the yield was significantly highest when lambda cyhalothrin 5 EC was sprayed at boll formation stage (6.04 q/ha), whereas the lowest yield was observed when NSE was sprayed at boll development stage (3.02 q/ha).

Second picking: The data presented regarding second picking of seed cotton in the plots treated with different insecticides at different crop stages to manage pink bollworm on cotton indicated that the significant differences were observed in various crop stages and insecticides. However, the interaction was non-significant.

Among the crop stages, the highest yield was recorded when the spraying of insecticides was initiated at (A_3) boll formation stage (4.57 q/ha). It was followed by (A_4) boll development stage (4.40 q/ha) and (A_2) flower formation stage (4.11 q/ha). The lowest seed cotton yield was noticed in (A_1) square development stage (3.89 q/ha).

In second picking, the plots sprayed with Azadirachtin 3000 ppm recorded significantly lowest yield (3.51 q/ha). The highest yield was recorded in the plots treated with lambda-cyhalothrin 5 EC (4.70 q/ha). It was followed by profenofos 40 + cypermethrin 4 EC (4.57 q/ha) and chlorantraniliprole 18.5 SC (4.26 q/ha).

Total seed cotton yield: The data on total seed cotton yield indicated that the significant differences were observed in various crop stages and insecticides. However, the interaction was non-significant. Among the crop stages, the highest yield was recorded when the insecticides were sprayed at (A_3) boll formation stage (10.12 q/ha). It was followed by (A_2) flower formation stage (9.35 q/ha) and (A_4) boll development stage (8.87 q/ha). The lowest yield was registered in (A_1) square formation stage (8.84 q/ha).

Among the insecticides, the yield was significantly highest in lambda- cyhalothrin 5 EC (10.49 q/ha). It was followed by profenofos 40 + cypermethrin 4 EC (10.05 q/ ha), profenofos50 EC (9.11 q/ ha) and chlorantraniliprole 18.5 SC (9.10 q/ha). The yield was significantly lowest in Azadirachtin 3000 ppm (7.74 q/ha).

The results indicated that the seed cotton yield was highest when lambda- cyhalothrin 5 EC sprayed at boll formation stage (11.60 q/ha), whereas the lowest yield was observed when NSE was sprayed at boll development stage (6.66 q/ha).

The literature on effect of different insecticides at different crop stages on pink bollworm is scanty. However, literature on the efficacy of different insecticides against pink bollworm is available. The present studies were discussed in accordance with available literature. Ghure *et al.*, (2008) [2] reported that lambda-cyhalothrin 5 EC, indoxacarb 14.5 SC, spinosad 45 SC and profenofos 50 EC were found highly effective against cotton bollworms. Mourad *et al.*, (1991) [4] reported that Karate (lambda-cyhalothrin) was the most effective pyrethroid and Fenval (fenvelarate) the least effective. Imran *et al.*, (2017) [3] reported that polytrin C (Profenofos 40 + Cypermethrin 4 EC) was effective on larvae of PBW in both Bt. and non-Bt. varieties.

In the present studies, lamada-cyhalothrin 5 EC was most effective against pink bollworm at different crop stages. It was followed by profenofos 40 + cypermethrin 4 EC, profenofos 50 EC, Chlorantraniliprole 18.5 SC and Azadirachtin 3000 ppm. The results are mostly in the conformity of above research workers. The present studies indicated that the spraying of lamada-cyhalothrin 5 EC at boll formation stage was most effective to manage pink bollworm on cotton.

References

1. Dhurua S, Gujar GT. Field-evolved resistance to Bt toxin Cry1Ac in the pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae), from India. Pest Management Science. 2011; 67(8):898-903.
2. Ghure ST, Kharbade SB, Patil SD. Bioefficacy of new pesticides against bollworm complex of cotton (*Gossypium spp*.) International Journal of. Plant Protection. 2008; 1(2):106-109.
3. Imran Ali Rajput *et al*., Effect of different synthetic pesticides against pink bollworm *Pectinophora gossypiella* (Saund.) on Bt and non-Bt cotton crop. Journal of Basic & Applied Sciences. 2017; 13:454-458.
4. Mourad MA, Omar MC, Mahran AA. Field potency of different insecticides against cotton bollworms. Egyptian Journal of Agricultural Research. 1991; 69:57-62.
5. Pearson EO. The Insect Pests of Cotton in Tropical Africa. Empire Cotton Growing Corporation and Commonwealth Institute of Entomology, London, 1958, 355.
6. Vakudavath CB Naik; Sujit Kumbhare; Sandhya Kranthi; Usha Satija and Keshav R Kranthi. 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 Management Science. 2018; 74(11):2544-2554.